Draft
Baseline Ecological Risk Assessment
Problem Formulation
Gulfco Marine Maintenance Superfund Site
Freeport, Texas

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consulting engineers and scientists

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BASELINE ECOLOGICAL RISK ASSESSMENT PROBLEM FORMULATION

FOR THE
GULFCO MARINE MAINTENANCE
SUPERFUND SITE
FREEPORT, TEXAS

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LIST OF ACRONYMS

AET – apparent effects threshold

AST – aboveground storage tank

AUF – area-use factor (unitless)

BERA – Baseline Ecological Risk Assessment

COPEC – contaminants of potential ecological concern

CSM – conceptual site model

DDD – dichlorodiphenyldichloroethylene

DDE – dichlorodiphenyldichloroethane

DDT – dichlorodiphenyltrichloroethane

EPA – United States Environmental Protection Agency

ERL – effects range low

ERM – effects range medium

GRG – Gulfco Remediation Group

HPAH – high-molecular weight polynuclear aromatic hydrocarbon

HQ – hazard quotient

LOAEL – lowest-observed-effects-level

LPAH – low-molecular weight polynuclear aromatic hydrocarbon

NEDR – Nature and Extent Data Report

NOAEL – no-observed-adverse-effects-level

NPL – National Priorities List

PAH – polynuclear aromatic hydrocarbon

PCB – polychlorinated biphenyl

PCL – Protective Concentration Level

PSA – Potential Source Area

QAPP – Quality Assurance Project Plan

RI/FS – Remedial Investigation/Feasibility Study

ROPC – receptors of potential concern

SAP – Sampling and Analysis Plan

SLERA – Screening-Level Ecological Risk Assessment

SMDP – Scientific Management Decision Point

SOW – Statement of Work

TCEQ – Texas Commission on Environmental Quality

TSWQS – Texas Surface Water Quality Standard

UAO – Unilateral Administrative Order

USFWS – United States Fish and Wildlife Service

WP/SAP – Work Plan and Sampling and Analysis Plan

EXECUTIVE SUMMARY

The purpose of the Baseline Ecological Risk Assessment (BERA) problem formulation for the former Gulfco Marine Maintenance, Inc. site in Freeport, Brazoria County, Texas (the Site) is to use the Screening-Level Ecological Risk Assessment (SLERA) results and additional site-specific information to determine the scope and goals of the BERA.

Problem formulation includes the following:

- Refining the preliminary list of Contaminants of Potential Ecological Concern (COPECs) identified in the SLERA;
- Further characterizing the ecological effects of the refined COPEC list;
- Reviewing and refining information on contaminant fate and transport, complete exposure pathways, and ecosystems potentially at risk;
- Determining assessment endpoints (i.e., the specific ecological values to be protected); and
- Developing a conceptual site model with risk questions for the ecological investigation to address.

Steps were taken to refine the COPEC list (i.e., modification of conservative exposure assumptions, consideration of background metals concentrations, and review of spatial COPEC distributions) and conduct literature research on the ecological effects of the refined list of COPECs, as well as their fate and transport characteristics relative to Site conditions. Subsequent to these steps, the following ecosystems have been identified as potentially at risk:

- <u>Localized wetland areas in the North Area of the Site and north of the Site.</u> The primary COPECs with hazard quotients (HQs) greater than one in wetland sediment are several polynuclear aromatic hydrocarbons (PAHs). Most of the PAH HQs exceedances are located in three areas: (1) a small area immediately northeast of the former surface impoundments; (2) a smaller area immediately south of the former surface impoundments; and (3) at a sample location in the southwest part of the North Area approximately 60 feet north of Marlin Avenue. Additionally, dissolved copper in wetland surface water in the first area (the area northeast of the former surface impoundments) exceeds its Texas Surface Water Quality Standard (TSWQS).

- <u>Localized areas of Intracoastal Waterway sediment within former Site barge slips.</u> The predominant COPECs in these areas, as reflected by HQ exceedances, are also PAHs.

The total PAH concentration was highest in the northernmost sample in the western barge slip. In the eastern barge slip, exceedances were limited to three PAHs , hexachlorobenzene, and the sum of high molecular weight PAHs (HPAHs) in one sample.

- Localized area of North Area soils south of the former surface impoundments. The COPECs in this area, where some buried debris was encountered in the shallow subsurface, are 4,4'-DDT and Aroclor-1254.

The risk questions developed for these areas through the BERA Problem Formulation are:

Barge Slip and Wetland sediments: Does exposure to COPECs in sediment adversely affect the abundance, diversity, productivity, and function of sediment invertebrates?

Wetland surface water: Does exposure to COPECs in surface water adversely affect the abundance, diversity, productivity, and function of water-column invertebrates?

North Area soils: Does exposure to COPECs in soil adversely affect the abundance, diversity, productivity, and function of soil invertebrates?

The approach for evaluating these risk questions, through the development and implementation of testable hypotheses and measures of effect and exposure based on this BERA problem formulation will be described in the BERA Work Plan and Sampling and Analysis Plan (SAP).

1.0 INTRODUCTION

The United States Environmental Protection Agency (EPA) named the former site of Gulfco Marine Maintenance, Inc. in Freeport, Brazoria County, Texas (the Site) to the National Priorities List (NPL) in May 2003. The EPA issued a modified Unilateral Administrative Order (UAO), effective July 29, 2005, which was subsequently amended effective January 31, 2008. The UAO required Respondents to conduct a Remedial Investigation and Feasibility Study (RI/FS) for the Site. Pursuant to Paragraph 37(d)(x) of the Statement of Work (SOW) for the RI/FS, included as an Attachment to the UAO, a Screening Level Ecological Risk Assessment (SLERA) was prepared for the Site (PBW, 2010). The Scientific/Management Decision Point (SMDP) provided in the SLERA concluded that the information presented therein indicated a potential for adverse ecological effects, and a more thorough assessment was warranted. This Baseline Ecological Risk Assessment (BERA) Problem Formulation has been prepared, consistent with Paragraphs 37(d)(xi) and (xii) of the UAO as the next step in that assessment. This report was prepared by Pastor, Behling & Wheeler, LLC (PBW), on behalf of LDL Coastal Limited LP (LDL), Chromalloy American Corporation (Chromalloy) and The Dow Chemical Company (Dow), collectively known as the Gulfco Restoration Group (GRG). Figure 1 provides a map of the Site vicinity, while Figure 2 provides a Site map.

1.1 REPORT PURPOSE

The ecological risk assessment process is outlined in the SOW (Page 20, Paragraphs 37(d)(xi) and (xii)). A diagram of the process as provided in EPA's Ecological Risk Assessment Process for Superfund (EPA, 1997) is provided in Figure 3. Problem formulation represents the third step in the eight-step ecological risk assessment process. The purpose of the problem-formulation phase is to refine the screening level problem formulation, and use the SLERA results and additional site-specific information to determine the scope and goals of the BERA.

As described in EPA, 1997, problem formulation includes the following:

- Refining the preliminary list of COPECs identified in the SLERA;
- Further characterizing the ecological effects of the refined COPEC list;
- Reviewing and refining information on contaminant fate and transport, complete exposure pathways, and ecosystems potentially at risk;
- Determining specific assessment endpoints (i.e., the specific ecological values to be protected); and

- Developing a conceptual model with risk questions that the ecological investigation will address.

The SMDP at the end of problem formulation is the identification and agreement on the conceptual model, including assessment endpoints, exposure pathways, and questions or risk hypotheses. The results of this SMDP are then used to select measurement endpoints for development of the BERA Work Plan and Sampling and Analysis Plan (WP/SAP).

1.2 SITE BACKGROUND

1.2.1 Site Description

The Site is located in Freeport, Texas at 906 Marlin Avenue (also referred to as County Road 756) (Figure 1). The Site consists of approximately 40 acres along the north bank of the Intracoastal Waterway between Oyster Creek (approximately one mile to the east) and the Texas Highway 332 bridge (approximately one mile to the west). The Site includes approximately 1,200 feet (ft.) of shoreline on the Intracoastal Waterway, the third busiest shipping canal in the US (TxDOT, 2001) that, on the Texas Gulf Coast, extends 423 miles from Port Isabel to West Orange.

Marlin Avenue divides the Site into two primary areas (Figure 2). For the purposes of descriptions in this report, Marlin Avenue is approximated to run due west to east. The property to the north of Marlin Avenue (the North Area) consists of undeveloped land and closed surface impoundments, while the property south of Marlin Avenue (the South Area) was developed for industrial uses with multiple structures, a dry dock, sand blasting areas, an aboveground storage tank (AST) tank farm, and two barge slips connected to the Intracoastal Waterway. The South Area is zoned as "W-3, Waterfront Heavy" by the City of Freeport. This designation provides for commercial and industrial land use, primarily port, harbor, or marine-related activities. The North Area is zoned as "M-2, Heavy Manufacturing."

Adjacent property to the north, west, and east of the North Area is undeveloped. Adjacent property to the east of the South Area is currently used for industrial purposes while to the west the property is currently vacant and previously served as a commercial marina. The Intracoastal Waterway bounds the Site to the south. Residential areas are located south of Marlin Avenue, approximately 300 feet west of the Site, and 1,000 feet east of the Site.

The Intracoastal Waterway is a major corridor for commercial barge traffic and other boating activities. Approximately 50,000 commercial vessel trips and 28 million short tons of cargo were transported on the Galveston to Corpus Christi section of the Intracoastal Waterway in 2006. The vast majority of this cargo (greater than 23 million tons) was petroleum, chemicals or related products (USACE, 2006). The Intracoastal Waterway design width and depth in the vicinity of the Site, based on USACE mean low tide datum, is 125 feet wide and 12 feet deep (USACE, 2008). The waterway is maintained by periodic dredging operations conducted by the USACE as frequently as every 20 to 38 months, and as infrequently as every 5 to 46 years (Teeter et al., 2002). A September 2008 survey indicated that actual channel depths in the 19-mile reach from Chocolate Bayou to Freeport Harbor, which includes the Site vicinity, ranged from 9.3 to 11.1 feet (USACE, 2008). According to the USACE (USACE, 2009), the Intracoastal Waterway in the immediate vicinity of the Site is not currently scheduled for dredging, although dredging is performed approximately every three to four years and the area to the west near Freeport Harbor (Intracoastal Waterway Mile 395) was dredged in 2009.

The South Area includes approximately 20 acres of upland that was created from dredged material from the Intracoastal Waterway. The two most significant surface features within the South Area are a Former Dry Dock and the AST Tank Farm (Figure 2). The remainder of the South Area surface consists primarily of former concrete laydown areas, concrete slabs from former Site buildings, gravel roadways and sparsely vegetated open areas with some localized areas of denser brush vegetation, particularly near the southeast corner of the South Area.

Some of the North Area is upland created from dredge spoil, but most of this area is considered wetlands, as per the United States Fish and Wildlife Service (USFWS) Wetlands Inventory Map (Figure 4) (USFWS, 2008). This wetland area generally extends from East Union Bayou to the southwest, to the Freeport Levee to the north, to Oyster Creek to the east (see Figure 1). The most significant surface features in the North Area are two ponds (the Fresh Water Pond and the Small Pond) and the closed former surface impoundments. The former surface impoundments and the former parking area south of the impoundments and Marlin Avenue comprise the vast majority of the upland area within the North Area (Figure 4).

Field observations during the RI indicate that the North Area wetlands are irregularly flooded with nearly all of the wetland area inundated by surface water that can accumulate to a depth of one foot or more during extreme high tide conditions, storm surge events, and/or in conjunction with surface flooding of Oyster Creek northeast of the Site (Figure 1). Due to a very low topographic slope and low permeability surface sediments, the wetlands are also very poorly draining and can retain surface water for prolonged periods after major rainfall events. Under normal tide conditions and during periods of normal or below normal rainfall, standing water within the wetlands (outside of the two ponds discussed below) is typically limited to a small, irregularly shaped area immediately north of the Fresh Water Pond and a similar area immediately south of the former surface impoundments (see Figure 2). Both of these areas can be completely dry, as was observed in June 2008. As such, given the absence of any appreciable areas of perennial standing water, the wetlands are effectively hydrologically isolated from Oyster Creek, except during intermittent, and typically brief, flooding events.

The Fresh Water Pond is approximately 4 to 4.5 feet deep and is relatively brackish (specific conductance of approximately 40,000 umhos/cm and salinity of approximately 25 parts per thousand). This pond appears to be a borrow pit created by the excavation of soil and sediment as suggested by the well-defined pond boundaries and relatively stable water levels. Water levels in the Fresh Water Pond are not influenced by periodic extreme tidal fluctuations as the pond dikes preclude tidal floodwaters in the wetlands from entering the pond, except for extreme storm surge events, such as observed during Hurricane Ike in September 2008.

The Small Pond is a very shallow depression located in the eastern corner of the North Area. The Small Pond is not influenced by daily tidal fluctuations and behaves in a manner consistent with the surrounding wetland, i.e., becomes dry during dry weather, but retains water in response to and following rainfall and extreme tidal events. Relative to the Fresh Water Pond, water in the Small Pond is less brackish based on specific conductance (approximately 14,000 umhos/cm) and salinity (approximately eight parts per thousand) measurements.

1.2.2 Site History

A detailed discussion of Site operational history was provided in the RI/FS Work Plan (PBW, 2006). Key elements of that discussion are noted herein. During the 1960s, the Site was used for occasional welding but there were no on-site structures (Losack, 2005). According to the Hazard Ranking Score Documentation (TNRCC, 2002), from 1971 through 1999, at least three different owners used the Site as a barge cleaning facility. Beginning in approximately 1971, barges were brought to the facility and cleaned of waste oils, caustics and organic chemicals, with these products stored in on-site tanks and later sold (TNRCC, 2002). Sandblasting and other barge repair/refurbishing activities also occurred on the Site. At times during the operation, wash waters were stored either on a floating barge, in on-site storage tanks, and/or in surface impoundments on Lot 56 of the Site. The surface impoundments were closed under the Texas Water Commission's (Texas Commission on Environmental Quality (TCEQ) predecessor agency) direction in 1982 (Carden, 1982).

Aerial spraying of the wetland areas north of Marlin Avenue, including the North Area, for mosquito control has historically been and continues to be performed by the Brazoria County Mosquito Control District and its predecessor agency, the Brazoria County Mosquito Control Department (both referred to hereafter as BCMCD). Aerial spraying for mosquito control has been performed over rural areas in the county since 1957 (Lake Jackson News, 1957). Historically, aerial spraying of a DDT solution in a "clinging light oil base" was performed from altitudes of 50 to 100 feet (Lake Jackson News, 1957). Recently BCMCD has been using Dibrom®, an organophosphate insecticide, with a diesel fuel carrier through a fogging atomizer application (Facts, 2006, 2008a, 2008b). Truck-based spraying has also been performed along Marlin Avenue. Both types of spraying were observed during the performance of Site RI activities.

1.3 REPORT ORGANIZATION

The organization for this report has been patterned after that suggested in EPA guidance (EPA, 1997). As such, Section 2.0 provides a refinement of the COPECs indentified in the SLERA. Section 3.0 characterizes the potential ecological effects of that refined list of COPECs. Section 4.0 describes significant fate and transport characteristics, ecosystems potentially at risk and complete exposure pathways. Section 5.0 describes assessment endpoints, and Section 6.0 provides the refined Conceptual Site Model and resulting risk decisions. The problem formulation SMDP is discussed in Section 7.0. Appendix A contains a table from the SLERA listing COPECs and media recommended for further evaluation in the BERA. Appendix B details a comparison of Site data to background. Appendices C through H contain the detailed calculation spreadsheets for the COPEC refinement described in Section 2.0.

2.0 REFINEMENT OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

The SLERA (PBW, 2010) concluded with the SMDP that there is a potential for adverse ecological effects from COPECs and a more thorough assessment through continuation of the ecological risk assessment process was warranted. The SLERA calculated HQs based on conservative screening-level assumptions, such as area-use factors (AUFs) of 100%, 100% contaminant bioavailability, maximum ingestion rates, and minimum body weights. Appendix A provides the SLERA tables identifying those COPECs with HQs greater than one.

As illustrated in Appendix A, the screening-level evaluation identified HQs greater than one for the following Site media and receptors:

- Invertebrate receptors in South Area soils (as represented by the earthworm);
- Invertebrate receptors in North Area soils (also represented by the earthworm);
- Invertebrate receptors in Background Area soils (again represented by the earthworm);
- Benthic receptors in Site Intracoastal Waterway sediment (as represented by the polychaetes *Capitella capitata*);
- Benthic receptors in Background Intracoastal Waterway sediment (also represented by the polychaetes *Capitella capitata*);
- Benthic receptors in Site wetlands sediment (as represented by the polychaetes *Capitella capitata*);
- Benthic receptors in Site pond sediment (as represented by the polychaetes *Capitella capitata*); and
- Avian carnivore receptors that might be exposed to pond sediment and surface water (as represented by the sandpiper).

Additionally, the maximum concentration in surface water of some COPECs is greater than the TCEQ ecological benchmark value or the TSWQS. These COPECs, acrolein, dissolved copper, and dissolved silver, are being further evaluated in the BERA and details are below. Upper trophic level receptors were determined to not be at risk from these COPECs in the SLERA.

Acrolein was measured (0.00929 mg/L) in one of four surface water samples from the wetlands. It was not detected in any surface water samples from the Intracoastal Waterway or the two ponds. The single detection is greater than the TCEQ ecological benchmark value of 0.005 mg/L by less than a factor of two. There is neither a TSWQS nor a recommended national water quality criterion from the EPA (2009) for chronic marine exposures. The maximum measured concentration of dissolved copper in surface water from the wetlands was 0.011 mg/L. It was not detected in any surface water samples from the Intracoastal Waterway or the two ponds. The maximum concentration is greater than the TSWQS of 0.0036 mg/L by about three-fold. The maximum measured concentration of dissolved silver in surface water from the ponds was 0.0029 mg/L. It was not detected in the surface water samples from the Site-related area of the Intracoastal Waterway or the wetlands. All detections are greater than the TCEQ ecological screening benchmark value of 0.00019 mg/L, the maximum being about 15 times greater. The maximum measured concentration of dissolved silver in surface water from the background area of the Intracoastal Waterway was 0.0058 mg/L. All detections are greater than the TCEQ ecological benchmark value of 0.00019 mg/L, the maximum being about 31 times greater. There is neither a TSWQS nor a recommended national water quality criterion from the EPA (2009b) for chronic marine exposures. The TCEQ ecological benchmark value is derived from the EPA (2009) acute marine recommended water quality criterion divided by a safety factor of 10.

2.1 REFINEMENT PROCEDURES AND RESULTS

As described in EPA, 1997, the purpose of the refinement step of problem formulation is to consider how the HQs in the SLERA would change when more realistic conservative assumptions are used. Consistent with that objective, the following modified assumptions are used here in the BERA to calculate revised HQs and refine the COPEC list, and includes the following:

- Use of average (instead of maxima) ingestion rates for both media and foods consumed;
- Use of average (instead of minima) body weights for food chain receptors; and
- Use of AUFs less than 100% when it can be demonstrated that a specific receptor's home range size is greater than the size of the Site.

The detailed spreadsheets in Appendices C through J describe the specific assumption modifications made for specific receptors and the resulting calculations.

All of the modified assumptions for the refinement pertain to non-sedentary ecological food-chain receptors. Results of the refinement calculations include the deletion of the avian carnivore (sandpiper) receptor for the pond sediment. The HQ calculated in the SLERA for this receptor in the pond was 1.2. With changes in the ingestion rates, body weights and AUFs, the refined lead HQ for the avian carnivore (sandpiper) receptor at the ponds was 0.96. So, the exposure pathway including media and food ingestion of lead by the avian carnivore (sandpiper) is dismissed from further evaluation. All other COPECs from the SLERA still remain for further evaluation.

2.2 BACKGROUND COMPARISON

As part of this problem formulation, Site metal COPECs in soil and/or sediment that are remaining after the refinement (barium, chromium, copper, lead, nickel, and zinc) were statistically compared to the same metal compounds in the background area for soil and sediment. This information was used in the development of Site-specific assessment endpoints (Section 5.0) and risk questions (Section 6.0), which will subsequently be used to develop testable hypotheses and measures as part of the study design in the WP/SAP. The COPEC concentrations in Site samples that are not statistically different from background concentrations are dismissed from further evaluation in the BERA (background data will still be discussed in the uncertainty section of the BERA report).

The soil background data were compared to soil data from the South and North Areas of the Site, as well as sediments from the North wetland and the North Area ponds. As described in the Nature and Extent Data Report (NEDR) (PBW, 2009), this comparison was appropriate based on similarities in composition and condition between background soil and sediments of the North wetlands area. Sediment and surface water data for the Intracoastal Waterway samples were compared to sediment and surface water data collected in the Intracoastal Waterway background area.

The background comparisons were performed using analysis of variance tests in accordance with EPA's *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA, 2002). The analysis of variance tests perform a comparison of the means analysis. The output of these background statistical comparison tests is provided in Appendix B. A summary of the statistical comparison conclusions is provided in Appendix Table B-1. The conclusion is that the Site concentrations of these metals COPECs are not different from the background concentrations for all metals evaluated. Nickel is retained for further evaluation because, as shown on Table B-1, it was not analyzed in the background samples. Therefore, the only metal COPEC in soil or sediment to be further evaluated is nickel in wetlands sediment.

For the COPECs in surface water (acrolein, dissolved copper, and dissolved silver), a statistical comparison of means between Site and background data sets was not performed due to the small data set sizes (four background Intracoastal Waterway surface water samples and six pond surface water samples). However, dissolved silver was detected in all four background surface water samples at concentrations ranging from 0.0043 mg/L to 0.006 mg/L, while the maximum reported dissolved silver concentration in pond surface water samples was a lower value of 0.0029 mg/L. Based on this observation that all the pond surface water sample concentrations were less than the minimum background concentration, dissolved silver in pond surface water is dismissed from further evaluation in the BERA.

2.3 SPATIAL DISTRIBUTION OF REMAINING COPECs

In order to evaluate potential hotspots and the spatial distributions of the remaining COPECs, HQ exceedances in individual samples are plotted by environmental medium in Figures 5 through 9. For soils, the HQs are based on no-observed-adverse-effects-levels (NOAELs). For sediments, HQs are based on Effects Range-Low (ERL) values, where available, or Apparent Effects Threshold (AET) values. The paragraphs below discuss the spatial trends of the HQ exceedances observed in the figures.

Figure 5 shows HQ exceedances for soil invertebrates in the South Area. As indicated on this figure, the highest HQs and most of the exceedances are located near the former dry dock in the northwestern part of the South Area. As shown on Figure 5, most of those samples are from the side embankments of the dry dock itself, where the soils consist of compacted engineered fill. Other samples with exceedances in the South Area, namely those off the northeastern end of the westernmost barge slip and between the western and eastern barge slips, are also from areas devoid of vegetation where the soil is compacted from engineered fill or for use as a driveway. The highest HQ is 26 for 4,4'-DDD in sample SA3SB17. All other HQs were less than or equal to 5 and nearly 75 percent were less than or equal to 2. These areas of side embankments, engineered fill, and driveways are not considered habitat for soil invertebrates. Therefore, the exposure pathway is considered incomplete and the associated COPECs (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, Aroclor-1254, and HPAH) are dismissed from further consideration for South Area soils in the BERA. At this point, South Area soils have no remaining COPECs, so this area/medium requires no further evaluation in the BERA.

Figure 6 shows HQ exceedances for soil invertebrates in the North Area. As indicated on this figure, the only HQs are 4,4'-DDT and Aroclor-1254 in the 1.5 to 2.0 foot depth interval sample from SB-204. This boring was located in an area where buried debris was observed and some of this debris (painted wood fragments and rubber) was observed in this specific sample interval.

Figure 7 shows HQ exceedances for benthic receptors in Site Intracoastal Waterway sediment. None of the HQs are greater than 5 and 75 percent are less than or equal to 2. As indicated on this figure, the HQs greater than one are nearly all PAHs, except for 4,4'-DDT in a sample next to the western boundary of the Site and hexachlorobenzene on the edge of the eastern barge slip, and most are associated with samples in the northern end of the western barge slip.

Figure 8 shows HQ exceedances for benthic receptors in Site wetland sediment. As shown in this figure, the predominant and highest HQs are associated with PAHs (both individual PAHs and low molecular weight PAHs (LPAH), HPAH, and total PAHs). Most of the PAH HQs are located in three areas: (1) a small area immediately northeast of the former surface impoundment (where most of the highest PAH HQs are observed; e.g., 2WSED2); (2) a smaller area immediately south of the former surface impoundments (e.g., 2WSED17); and (3) at sample location NB4SE08 in the southwest part of the North Area. The three highest HQs, all located in the area north of the former surface impoundments, are for dibenz(a,h)anthracene. Figure 9 shows HQ exceedances for benthic receptors in pond sediment. As shown in this figure, the sole HQ is 4,4'-DDT in the southernmost sample from the Small Pond.

There are two COPECs, acrolein and dissolved copper, with maximum concentrations that exceed their respective ecological screening benchmark and TSWQS. Acrolein was only detected once in four surface water samples from the wetlands area, and not detected in any other Site samples. Its concentration is slightly less than twice the benchmark value, so if a HQ were computed it would be rounded to 2. Dissolved copper was detected in three of four surface water samples from the wetlands area. All of the detections are greater than the TSWQS, the highest being about three times greater. Acrolein is being dismissed at this step because of its single detection in Site surface water and minimal exceedance above the benchmark value. Dissolved copper is being retained for further evaluation in the BERA.

After the three refinement steps detailed above, the remaining COPECs, and their environmental medium and location, are listed in Tables 1 and 2.

3.0 CHARACTERIZATION OF ECOLOGICAL EFFECTS

The SLERA (PBW, 2010) included a literature search of potential ecological effects from the initial COPECs. As part of problem formulation in the BERA, additional literature information related to the remaining Site COPECs was obtained and reviewed.

Upper trophic level receptors are no longer considered to be at risk of adverse effects, so toxicological endpoints for these receptors, such as lowest-observed-adverse-effects-levels (LOAELs), did not need to be sought from the literature. Endpoint values similar to LOAELs that are used for invertebrates in sediment, Effects Range-Medium (ERM) were obtained from the scientific literature (Buchman, 2008.). Midpoint values were computed from these ERM values and the ERL values used in the SLERA and are listed in Table 3 for later use in the BERA. If an ERL value was not found for a particular COPEC, then the AET value (also used in the SLERA) is listed.

A number of researchers have performed studies to determine AETs, which are measures of sediment effect levels developed using the empirical data from the results of toxicity tests and benthic community structure. They are derived by determining, for a given chemical within a data set, the chemical sediment concentration above which a particular adverse biological effect is always statistically significant relative to a designated reference location. ERLs and ERMs are also statistically-derived sediment benchmark values based on a variety of benthic endpoints including mortality, community structure, reproductive, and other effects. ERL concentrations represent concentrations above which toxic effects to sediment organisms are possible, while ERM concentrations represent concentrations above which toxic effects are probable.

4.0 CONTAMINANT FATE AND TRANSPORT AND ECOSYSTEMS POTENTIALLY AT RISK

The SLERA (PBW, 2010) included a preliminary evaluation of contaminant fate and transport, ecosystems potentially at risk, and complete exposure pathways for COPECs and media that might pose an adverse risk to terrestrial and aquatic receptors. The exposure pathways and ecosystems associated with the assessment endpoints carried forward from the SLERA were evaluated in more detail in this problem formulation. Consistent with EPA (1997), this evaluation also considered the possible reduction of potentially complete, but less significant, exposure pathways to examine the critical exposure pathways, where appropriate. The findings of this evaluation are presented below.

4.1 CONTAMINANT FATE AND TRANSPORT

Additional information was acquired from the scientific literature regarding the fate and transport of the remaining COPECs. Specifically, details about transport mechanisms in terrestrial and aquatic systems similar to those found at the Site were obtained and are discussed below.

4.1.1 Potential Transport Mechanisms in Terrestrial Systems

Potentially significant routes of migration for Site COPECs relative to terrestrial systems occur in the primary transport media of air and surface water (runoff). Surface water runoff, or overland flow, can carry dissolved COPECs in solution or move COPECs adsorbed to soil particles from one portion of the Site to another, depending on surface topography. The same mechanisms described for overland flow in the wetlands (Section 4.1.2) apply to the South Area and the upland areas of the North Area. Airborne transport of Site COPECs is possible via entrainment of COPEC-containing particles in wind. This pathway is a function of particle size, chemical concentrations, moisture content, degree of vegetative cover, surface roughness, size and topography of the source area, and meteorological conditions (wind velocity, wind direction, wind duration, precipitation, and temperature). Movement of airborne contaminants occurs when wind speeds are high enough to dislodge particles; higher wind velocities are required to dislodge particles than are necessary to maintain suspension.

4.1.2 Potential Transport Mechanisms in Estuarine Wetland and Aquatic Systems

Potentially significant routes of migration for Site COPECs relative to wetland and aquatic systems occur in the primary transport media of surface water and sediment. The primary surface water/sediment pathways for potential contaminant migration from Site potential source areas (PSAs) are: (1) erosion/overland flow to wetland areas north and east of the Site from the North Area due to rainfall runoff and storm/tide surge; and (2) erosion/overland flow to the Intracoastal Waterway from the South Area as a result of rainfall runoff and extreme storm surge/tidal flooding events.

The primary North Area PSAs, the former surface impoundments, were closed and capped in 1982. Thus, potential migration from these areas to the adjacent wetlands would have to have occurred during the operational period of the impoundments, potentially when discharges from the impoundments in July 1974 and August 1979 reportedly "contaminated surface water outside of ponds" and "damaged some flora north of the ponds" (EPA, 1980). Although not associated with Site operations, the historical and ongoing spraying of pesticides in the wetland areas for mosquito control could represent a potential source of DDT and PAHs (associated with the light oil base and diesel carrier used in spraying then and now, respectively) to the wetlands.

Overland flow during runoff events occurs in the direction of topographic slope. Overland flow during runoff events occurs if soils are fully saturated and/or precipitation rates are greater than infiltration rates; therefore, this type of flow is usually associated with significant rainfall events. As a result of the minimal slope at the site, overland flow during more routine rainfall events is generally low, with runoff typically ponding in many areas of the Site. Extreme storm events, such as Hurricane Ike in September 2008, can inundate the Site, resulting in overland flow during both storm surge onset and recession. During less extreme storm surge events or unusually high tides, tidal flow to wetland areas on and adjacent to the Site occurs from Oyster Creek northeast of the Site (Figure 1); however, the wetland areas are more typically hydrologically isolated from Oyster Creek.

Potential contaminant migration in surface water runoff can occur as both sediment load and dissolved load; therefore, both the physical and chemical characteristics of the contaminants are important with respect to surface-water/sediment transport. The low topographic slope of the Site and adjacent areas is not conducive to high runoff velocities or high sediment loads.

Consequently, surface soil particles would not be readily transported in the solid phase. Additionally, the vegetative cover in the North Area is not conducive to significant soil erosion and resulting sediment load transport with surface water in these areas. Dissolved loads associated with surface runoff from the North Area would likewise be expected to be minimal due to the aforementioned absence of exposed PSAs, and the relatively low solubilities of those COPECs (primarily, pesticides and PAHs) that are present.

4.1.3 COPEC-Specific Fate and Transport Characteristics

PAHs. A detailed literature review related to PAH fate and transport characteristics in similar settings to the Site was performed for the ecological problem formulation for the Alcoa(Point Comfort)/Lavaca Bay Superfund Site (Alcoa, 2000). That document (used with permission) provided significant parts of the summary presented herein. Due to their low solubility and relatively high affinity for adsorption to soils, sediment organic matter, PAHs in the aquatic environment are primarily associated with particulate matter and sediments (Neff, 1985). PAHs sorb to both inorganic and organic surfaces, although adsorption to organic surfaces tends to be most important. PAH adsorption to particulate mater, especially HPAHs, is a primary mechanism for removing these compounds from the water column, resulting in subsequent deposition to sediments. PAH sorption to sediments is strongly influenced by sediment organic carbon content. PAH sorption is also influenced by particle size (Karickhoff et al., 1979); the smaller the particle size, the greater the adsorption potential.

Benthic organisms accumulate PAHs by two primary exposure routes: (1) bioconcentration through transport across biological membranes exposed to aqueous phase PAHs (i.e., pore water); and (2) bioaccumulation through direct food or sediment ingestion. For benthic organisms, direct ingestion of food and/or sediments is often the most significant exposure pathway for HPAHs (Niimi and Dookhran, 1989; Eadie et al., 1985; Weston, 1990), while pore water is likely a more significant route for LPAH accumulation (Meador et al., 1995b; Adams, 1987; Landrum, 1989). Differences in feeding regime (i.e., epibenthic, infaunal) also influence which exposure route is most significant.

As a result of these issues, PAH accumulation by benthic organisms can vary. In addition, the degree to which organisms accumulate PAHs depends on their ability to metabolize these compounds. Although some organisms metabolize PAHs (e.g., fish and mammals), many benthic invertebrates are limited in their ability to metabolize PAHs (Meador et al., 1995a; Landrum, 1982; Frank et al., 1986).

In general, there is little evidence to suggest PAHs biomagnify in aquatic systems. However, because of the limited ability of invertebrates to metabolize PAHs, some biomagnification may occur in lower trophic levels (Meador et al., 1995a; McElroy et al., 1989; Broman et al., 1990; Suede et al., 1994). Although metabolism often results in detoxification, some PAH metabolites are more toxic than parent materials; however, the degree to which these metabolites are accumulated by aquatic organisms is unknown.

Organochlorine Pesticides and PCBs. Organochlorine pesticides and PCBs are of interest in characterizations of risk to ecological receptors due to the affinity of these compounds to sorb tightly onto soils and sediments and persist for long periods of time in the environment. The degradation of organochlorine compounds in the environment is dependent on the degree and pattern of chlorination, with compounds possessing five or more chlorine atoms more persistent in the environment than those with fewer chlorine atoms.

Benthic invertebrate communities are particularly susceptible to organochlorine compound impacts as consequence of ingestion of sediment particles and exchange of PCBs directly from the particles. The silt and clay content of sediments can have a significant influence on the bioavailability of organochlorine compounds, with low silt and clay content sediments exhibiting decreased effects on benthic communities (Eisler, 1986). Due to bioaccumulative properties, organochlorine compounds cycle readily from sediment sources into upper trophic levels. This class of compounds are soluble in lipids and partition readily into the fatty tissues of higher-level consumers, with the ability to be metabolized decreasing as the number of substituted chlorines decreases. For highly substituted compounds, metabolism is less likely and accumulation may continue indefinitely. The fate of organochlorine compounds within biologic systems is wide ranging as a result of differences in the ability to accumulate, metabolize, and eliminate specific isomers.

4.2 ECOSYSTEMS POTENTIALLY AT RISK

Based on the remaining HQ exceedances listed in Tables 1 and 2, and in consideration of the ecological effects literature evaluation (Section 3.0), the fate and transport characteristics (Section 4.1), and the nature of the ecosystems themselves, the following ecosystems have been identified as potentially at risk:

- Localized wetland areas in the North Area and north of the Site. The primary COPECs with HQ exceedances in wetland sediment are several PAHs (Table 2). As shown on Figure 8, most of the PAH HQs are located in three areas: (1) a small area immediately northeast of the former surface impoundments (where most of the highest PAH HQs are observed; e.g., 2WSED2); (2) a smaller area immediately south of the former surface impoundments (e.g., 2WSED17); and (3) at sample location NB4SE08 in the southwest part of the North Area approximately 60 feet north of Marlin Avenue. Additionally, dissolved copper in wetland surface water in the first area (the area northwest of the former surface impoundments) exceeds its TSWQS.

- Localized areas of Intracoastal Waterway sediment within the former barge slips. The predominant COPECs in these areas, as reflected by HQ exceedances (Table 2), are PAHs. The total PAH concentration (5.62 mg/kg) was highest in the northernmost sample in the western barge slip. In the eastern barge slip, exceedances were limited to three PAHs , hexachlorobenzene, and HPAHs in one sample.

- Localized area of North Area soils south of the former surface impoundments. As previously described (Section 2.3), the only HQs are 4,4'-DDT and Aroclor-1254 in the 1.5 to 2.0 foot depth interval sample from SB-204. This boring was located in an area where buried debris was observed and some of this debris (painted wood fragments and rubber) was observed in this specific sample interval.

5.0 SITE-SPECIFIC ASSESSMENT ENDPOINTS

Assessment endpoints are explicit expressions of the ecological resource to be protected for a given receptor of potential concern (EPA, 1997). Several assessment endpoints were identified in the SLERA to focus the screening evaluation on relevant receptors rather than attempting to evaluate risks to all potentially affected ecological receptors. As part of this BERA problem formulation, these assessment endpoints were re-evaluated based on the remaining environmental media and receptors of potential concern.

5.1 TERRESTRIAL ASSESSMENT ENDPOINTS

The terrestrial portion associated with the Site that remains of concern is a small area of land south of the former surface impoundments. The environmental value of upland lands is related to its ability to support plant communities, soil microbes/detritivores, and wildlife. Based on the steps taken in the refinement (Section 2.0) and new information obtained about COPEC fate and transport and ecosystems at risk (Section 4.0), the following remains the assessment endpoint for the BERA (Table 4):

- *Soil invertebrates abundance, diversity, and productivity* (as decomposers and food chain base, among others) are ecological values to be preserved in a terrestrial ecosystem because they provide a mechanism for the physical and chemical breakdown of detritus for microbial decomposition (remineralization), which is a vital function.

5.2 ESTUARINE WETLAND AND AQUATIC ASSESSMENT ENDPOINTS

The estuarine wetland habitat for the Site extends over the majority of the North Area while the Intracoastal Waterway (i.e., aquatic habitat) is south of the Site. Wetlands are particularly important habitat because they often serve as a filter for water prior to it going into another water body. They are also important nurseries for fish, crab, and shrimp, and they act as natural detention areas to prevent flooding. The environmental value for these areas is related to their ability to support wetland plant communities, microbes/benthos/detritivores in the sediment, and wildlife. Based on the steps taken in the refinement (Section 2.0) and new information obtained about COPEC fate and transport and ecosystems at risk (Section 4.0), the following remains the assessment endpoint for the BERA (Table 4):

- *Benthos abundance, diversity, and productivity* are values to be preserved in estuarine ecosystems because these organisms provide a critical pathway for energy transfer from detritus and attached algae to other omnivorous organisms (e.g., polychaetes and crabs) and carnivorous organisms (e.g., black drum and sandpipers), as well as integrating and transferring the energy and nutrients from lower trophic levels to higher trophic levels. The most important service provided by benthic detritivores is the physical breakdown of organic detritus to facilitate microbial decomposition.

6.0 CONCEPTUAL SITE MODEL AND RISK QUESTIONS

6.1 CONCEPTUAL SITE MODEL

Preliminary Conceptual Site Models (CSMs) for the aquatic and terrestrial ecosystems were described in the SLERA. During problem formulation in the BERA, these CSMs have been updated to consider the results of the COPEC refinement (Section 2.0), expanded review of potential ecological effects of those COPECs (Section 3.0), and the more detailed fate and transport evaluation (Section 4.0). Updated CSMs based on these considerations are shown on Figures 10 and 11. These CSMs are discussed below.

The identification of potentially complete exposure pathways is performed to evaluate the exposure potential as well as the risk of effects on ecosystem components. In order for an exposure pathway to be considered complete, it must meet all of the following four criteria (EPA, 1997):

- A source of the contaminant must be present or must have been present in the past.
- A mechanism for transport of the contaminant from the source must be present.
- A potential point of contact between the receptor and the contaminant must be available.
- A route of exposure from the contact point to the receptor must be present.

Exposure pathways can only be considered complete if all of these criteria are met. If one or more of the criteria are not met, there is no mechanism for exposure of the receptor to the contaminant. The potentially complete and significant exposure pathways and receptors that match the current assessment endpoints are shown in the CSM for the terrestrial and estuarine wetland and aquatic ecosystems (Figures 10 and 11, respectively).

In general, biota can be exposed to chemical stressors through direct exposure to abiotic media or through ingestion of forage or prey that have accumulated contaminants. Exposure routes are the mechanisms by which a chemical may enter a receptor's body. Possible exposure routes include 1) absorption across external body surfaces such as cell membranes, skin, integument, or cuticle from the air, soil, water, or sediment; and 2) ingestion of food and incidental ingestion of soil, sediment, or water along with food. Absorption is especially important for plants and aquatic life.

The terrestrial ecosystem CSM (Figure 10) begins with historical releases of the COPECs from the former surface impoundments and operations areas in the North and South Areas. Soil became contaminated with the COPECs and contaminated soil was transported from its original location to other portions of the Site via the transport mechanisms of surface runoff and airborne suspension/deposition. The significant potential receptors (soil invertebrates) are then exposed to soils in their original location or otherwise via direct contact or ingestion of soil.

The aquatic ecosystem CSM (Figure 11) begins with historical releases of the COPECs from barge cleaning operations that impacted sediment in the barge slips of the Intracoastal Waterway and surface water and sediment in the North Area wetlands. These areas were impacted via the primary release mechanisms of direct discharge from past operations, surface runoff, and particulate dust/volatile emissions. Tidal flooding and rainfall events created secondary release mechanisms of resuspension/deposition, bioirrigation, and bioturbation, such that other areas of surface water and sediment became contaminated. The significant potential receptors (sediment and water-column invertebrates) are then exposed to the contaminated surface water and sediment in their original location or otherwise via direct contact or ingestion of surface water and sediment.

6.2 RISK QUESTIONS

As described in ecological risk assessment guidance (EPA, 1997), risk questions for the BERA are questions about the relationships among assessment endpoints and their predicted responses when exposed to contaminants. As such, the risk questions are based on the assessment endpoints and provide a basis for the ecological investigation study design developed in the BERA WP/SAP.

The overarching risk question to be evaluated in the BERA is whether Site-related contaminants are causing, or have the potential to cause, adverse effects on the invertebrates in North Area soils and on benthos and zooplankton of the wetlands area and the barge slips of the Intracoastal Waterway. For problem formulation, this overarching question is refined into a series of specific questions referencing specific COPECs and the assessment endpoint. Preliminary risk questions were developed for the SLERA (PBW, 2010). Based on the information developed for this problem formulation, these risk questions were refined to the questions identified in Table 4 of this report. Testable hypotheses and measures of effect for these questions will be developed in the WP/SAP. The risk questions of concern for the end of the BERA Problem Formulation are the following:

- Does exposure to COPECs in soil adversely affect the abundance, diversity, productivity, and function of soil invertebrates?

- Does exposure to COPECs in sediment and surface water adversely affect the abundance, diversity, productivity, and function of sediment and water-column invertebrates?

7.0 SCIENTIFIC MANAGEMENT DECISION POINT

The final component of BERA problem formulation is an SMDP. The SMDP entails identification and agreement on the COPECs, assessment endpoints, exposure pathways, and risk questions that have been described in previous sections. As discussed above, the ecosystems potentially at risk for adverse effects are 1) localized areas of sediment within the Site barge slips (primarily due to PAHs); 2) localized wetland areas (primarily due to PAHs and pesticides), mainly northeast of the former surface impoundments and north of Marlin Avenue; and 3) a localized area of soils south of the former surface impoundments in the North Area. The list of COPECs that will be addressed in the WP/SAP to obtain additional site-specific information is presented in Table 5.

8.0 REFERENCES

Adams, W.J., 1987. Bioavailability of Neutral Lipophilic Organic Chemicals Contained on Sediments: A Review. In K.L. Dickson, A.W. Maki, and W.A. Brungs, eds. Fate and Effects of Sediment-Bound Chemicals in Aquatic Systems. Sixth Pelleston Workshop. Pergamon Press: Elmsford, New York. Pp. 219-244.

Alcoa , 2000. Final Baseline Risk Assessment Report, Alcoa (Point Comfort)/Lavaca Bay Superfund Site. May 19.

Broman, D., C. Nat, I. Undbergh, and Y Zebuhr, 1990. An in situ study on the distribution, biotransformation and flux of polycyclic aromatic hydrocarbons (PAH) in an aquatic food chain (Seston - Mytilus edulis-Somaterla mollissima L.) from the Baltic: an ecotoxicological perspective. Environ. Toxicol. Chem. 9:429.

Brazoria County Facts (Facts), 2006. "Pilots Take to Skies to Eradicate Mosquitoes." June 16.

Brazoria County Facts (Facts), 2008a. "County District Responds to Mosquito Outbreak." September 8.

Brazoria County Facts (Facts), 2008b. "State Adds to Mosquito-Spraying Efforts." September 26.

Buchman, M.F., 2008. NOAA Screening Quick Reference Tables (SQuiRTs). NOAA OR&R Report 08-1, Seattle, WA. Office of Response and Restoration Division. National Atmospheric Administration. 34 pages.

Carden, Clair A., 1982. Fish Marine Services, Freeport, Texas, Pond Closure Certification. August 18.

Eadie, B.J., W.R. Faust, P.F. Landrum, and N.R. Morehead, 1985. Factors affecting bioconcentration of PAH by the dominant benthic organism of the Great Lakes. In H.W. Cooke and A.J. Dennis, eds. Polynuclear Aromatic Hydrocarbons: Eighth International Symposium on Mechanisms, Methods, and Metabolism. Battelle Press: Columbus, Ohio. Pp. 363-377.

Eisler, R. 1986 . Polychlorinated biphenyl hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service Biological Report 85(1.7).

Karickhoff, S.W., D.S. Brown, and T.A. Scott, 1979. Sorption of hydrophobic pollutants on natural sediments. Water Res. 13:241-248.

Lake Jackson News, 1957. "Spray Plane Swats Mosquito via Two Day Oil Spray Job." August 8.

Landrum, P.F., 1982. Uptake, deprivation and biotransformation of anthracene by the SCUD, Pontopoveia hoyi. Chemosphere. 11:1049-1057.

Landrum, P.F., 1989. Bioavailability and toxicokinetics of polycyclic aromatic hydrocarbons sorbed to sediments for the amphipod Pontoporeia hoyi. Environ. Sci. Technol. 23:588-595.

Losack, Billy, 2005. Personal communication with Pastor, Behling & Wheeler, LLC. July.

McElroy, A.E., J.W. Farrington, and J.M. Teal, 1989. Bioavailability of PAHs in the aquatic environment. In U. Varanasi, ed. Metabolism of Polynuclear Aromatic Hydrocarbons (PAHs) In the Aquatic Environment. CRC Press: Boca Raton, Florida. Pp 1-39.

Meador, J.P., E. Casillas, C.A. Sloan, and U. Varanasi, 1995a. Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. Rev. Environ. Contam. Toxicol. 145:79-165.

Meador, J.P., E. Casillas, C.A. Sloan, and U. Varanasi, 1995b. Comparative bioaccumulation of polycyclic aromatic hydrocarbons from sediment by two infaunal organisms. Mar. Ecol. Prog. Ser. 123:107-124.

Neff, J.M.,1985. Polycyclic aromatic hydrocarbons. In G. Rand and S.R. Petrocelli, eds., Fundamentals of Aquatic Toxicology:: Methods and Applications. Hemisphere Publishing Co.: New York, New York.

Niimi, A.J. and G.P. Dookhran, 1989. Dietary absorption efficiencies and elimination rates of polycyclic aromatic hydrocarbons in rainbow trout (Salmo gairdneri). Environ. Toxicol. Chem. 8:719:722.

Pastor, Behling & Wheeler, LLC (PBW), 2006. Final RI/FS Work Plan, Gulfco Marine Maintenance Site, Freeport, Texas. May 16.

Pastor, Behling & Wheeler, LLC (PBW), 2009. Final Nature and Extent Data Report. Gulfco Marine Maintenance Superfund Site, Freeport, Texas. May 20.

Pastor, Behling & Wheeler, LLC (PBW), 2010. Final Screening-Level Ecological Risk Assessment Report, Gulfco Marine Maintenance Site, Freeport, Texas. March 10.

Suede, B.C., J.A. Boraczck, R.K. Peddicord, P.A. Clifford, and T.M. Dillon, 1994. Trophic transfer and biomagniflcation potential of contaminants in aquatic ecosystems. Rev. Env. Contam. Toxicol. 136:21-89.

Teeter, A.M., Brown, G.L., Alexander, M.P., Callegan, C.J., Sarruff, M.S., and McVan, D.C., 2002. Wind-wave resuspension and circulation of sediment and dredged material in Laguna Madre, Texas, ERDC/CHL TR-02-XX, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Texas Department of Transportation (TxDOT), 2001. Transportation Multimodal Systems Manual. September.

Texas Natural Resource Conservation Commission (TNRCC), 2002. HRS Documentation Record, Gulfco Marine Maintenance, Inc. Freeport, Brazoria County, Texas TXD 055 144 539. Prepared in cooperation with the U.S. Environmental Protection Agency. February.

United States Army Corps of Engineers (USACE), 2006. Waterborne Commerce of the United States, Calendar Year 2006. IWR-WCUS-06-2.

United States Army Corps of Engineers (USACE), 2008. October 2008 Hydrograph Bulletin, Channels With Project Depths Under 25 Feet, Galveston District. October, 2008.

United States Army Corps of Engineers (USACE), 2009. Personal communication with Ms. Alicia Rea. July.

United States Environment Protection Agency (EPA), 1980. Potential Hazardous Waste Site Inspection Report. July 15.

United States Environment Protection Agency (EPA), 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final). OSWER Directive 9285.7-25. EPA/540/R-97/006. June.

United States Environmental Protection Agency (EPA), 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. Office of Emergency and Remedial Response. EPA 540-R-01-003. OSWER 9285.7-41. September.

United States Environmental Protection Agency (EPA), 2009. National Recommended Water Quality Criteria. Office of Water, Office of Science and Technology. Accessed online 12/20/2009 at http://www.epa.gov/ost/criteria/wqctable/.

United States Fish and Wildlife Service (USFWS), 2008. National Wetlands Inventory, Online Wetlands Mapper. http://wetlandsfws.er.usgs.gov/wtlnds/launch.html. Accessed July 9, 2008.

Weston, D.P., 1990. Hydrocarbon bioaccumulation from contaminated sediment by the deposit feeding polychaete Abarenicola pacifica. Mar. Biol. 107:159-169.

TABLES

TABLE 1
UPDATED ECOLOGICAL HAZARD QUOTIENTS EXCEEDING ONE FOR SOIL

MEDIA	RECEPTOR	CHEMICAL OF POTENTIAL ECOLOGICAL	TOXICITY VALUE*	EXPOSURE POINT CONCENTRATION (mg/kg)	BASIS FOR EPC	EHQ
North Area Soil	Invertebrate (Earthworm)	4,4'-DDT Aroclor-1254	NOAEL NOAEL	3.95E-01 6.35E+00	Maximum Maximum	9.2 2.5

Notes:
EHQ - ecological hazard quotient
NOAEL - no observable adverse effects level
PAH - polynuclear aromatic hydrocarbon
HPAH - high-molecular weight PAH
*See Table D-3 in Appendix D for further information about the toxicity reference values used in the risk calculations.

TABLE 2
UPDATED ECOLOGICAL HAZARD QUOTIENTS EXCEEDING ONE FOR SEDIMENT AND SURFACE WATER

MEDIA	RECEPTOR	CHEMICAL OF POTENTIAL ECOLOGICAL CONCERN	TOXICITY VALUE*	EXPOSURE POINT CONCENTRATION (mg/kg)	BASIS FOR EPC	EHQ
Intracoastal Waterway Sediment	Polychaetes (*Capitella*	4,4'-DDT	ERL	3.32E-03	Maximum	3.3
		Acenaphthene	ERL	6.31E-02	Maximum	1.4
		Benzo(a)anthracene	ERL	3.95E-01	Maximum	1.5
		Chrysene	ERL	4.75E-01	Maximum	1.2
		Dibenz(a,h)anthracene	ERL	2.35E-01	Maximum	3.7
		Fluoranthene	ERL	8.04E-01	Maximum	1.3
		Fluorene	ERL	4.60E-02	Maximum	2.4
		Hexachlorobenzene	AET	3.19E-02	Maximum	5.3
		Phenanthrene	ERL	5.08E-01	Maximum	2.1
		Pyrene	ERL	8.62E-01	Maximum	1.3
		LPAH	ERL	7.10E-01	Maximum	1.3
		HPAH	ERL	4.91E+00	Maximum	2.9
		Total PAH	ERL	5.62E+00	Maximum	1.4
		Dibenz(a,h)anthracene	midpoint ERL/ERM	2.35E-01	Maximum	1.5
Wetlands Sediment	Polychaetes (*Capitella*	2-Methylnaphthalene	ERL	4.30E-01	Maximum	6.1
		4,4'-DDT	ERL	9.22E-03	Maximum	8
		Acenaphthene	ERL	1.33E-01	Maximum	8.3
		Acenaphthylene	ERL	5.45E-01	Maximum	12.4
		Anthracene	ERL	3.34E-01	Maximum	3.9
		Benzo(a)anthracene	ERL	9.93E-01	Maximum	3.8
		Benzo(a)pyrene	ERL	1.30E+00	Maximum	3
		Benzo(g,h,i)perylene	AET	1.94E+00	Maximum	2.9
		Chrysene	ERL	4.05E+00	Maximum	10.5
		Dibenz(a,h)anthracene	ERL	2.91E+00	Maximum	45.9
		Endrin Aldehyde	ERL	1.00E-02	Maximum	3.8
		Endrin Ketone	ERL	1.30E-02	Maximum	4.9
		Fluoranthene	ERL	2.17E+00	Maximum	3.6
		Fluorene	ERL	1.39E-01	Maximum	7.3
		gamma-Chlordane	ERL	3.60E-03	Maximum	1.6
		Indeno(1,2,3-cd)pyrene	AET	1.94E+00	Maximum	3.2
		Nickel	ERL	2.77E-01	Maximum	1.3
		Phenanthrene	ERL	1.30E+00	Maximum	5.4
		Pyrene	ERL	1.64E+00	Maximum	2.5
		LPAH	ERL	1.15E+00	Maximum	2.1
		HPAH	ERL	1.39E+01	Maximum	8.2
		Total PAHs	ERL	1.51E+01	Maximum	3.8
		2-Methylnaphthalene	midpoint ERL/ERM	4.30E-01	Maximum	1.2
		Acenaphthylene	midpoint ERL/ERM	5.45E-01	Maximum	1.6
		Benzo(a)anthracene	midpoint ERL/ERM	9.93E-01	Maximum	1.1
		Benzo(a)pyrene	midpoint ERL/ERM	1.30E+00	Maximum	1.3
		Chrysene	midpoint ERL/ERM	4.04E+00	Maximum	2.5
		Dibenz(a,h)anthracene	midpoint ERL/ERM	2.91E+00	Maximum	18
		Phenanthrene	midpoint ERL/ERM	1.30E+00	Maximum	1.5
		HPAH	midpoint ERL/ERM	1.39E+01	Maximum	2.5
Wetlands Surface Water	Aquatic Invertebrates	Dissolved copper	TSWQS	1.10E-02	Maximum	3.1
Pond Sediment	Polychaetes (*Capitella*	4,4'-DDT	ERL	1.57E-03	Maximum	1.3

Notes:
ERL - effects range low ERM - effects range medium AET - apparent effects threshold
EHQ - ecological hazard quotient
PAH - polynuclear aromatic hydrocarbon LPAH - low-molecular weight PAH HPAH - high-molecular weight PAH
*See Tables E-2, F-2, and G-2 in Appendices for further information about the toxicity reference values used in the risk calculations.

TABLE 3 REVISED SEDIMENT TOXICITY VALUES

Chemicals of Potential Ecological Concern	Midpoint of ERL/ERM
4,4'-DDT	0.032045
Acenaphthene	0.258
Acenaphthylene	0.342
Anthracene	0.59265
Arsenic	39.1
Benzo(a)anthracene	0.9305
Benzo(a)pyrene	1.015
Benzo(g,h,i)perylene *	1.8
Chrysene	1.592
Copper	152
Dibenz(a,h)anthracene	0.1617
Endrin Aldehyde **	0.01
Endrin Ketone **	0.01
Fluoranthene	2.85
Fluorene	0.2795
gamma-Chlordane	0.003525
Hexachlorobenzene *	0.006
Indeno(1,2,3-cd)pyrene *	0.6
Lead	132.35
Nickel	36.25
Phenanthrene	0.87
Pyrene	1.6325
Zinc	280
LPAH	1.856
HPAH	5.65
TOTAL PAHs	11.86105

Notes:
Values from NOAA SQUIRTS table (Buchman, 2009).
* No Effects Range -Low (ERL) or Effects Range - Medium (ERM) available, so Apparent Effects Treshold (AET) is represented.
** midpoint of freshwater sediment Threshold Effects Level (TEL) and Probable Effects Level (PEL). No marine sediment toxicity benchmark values available.

TABLE 4
ASSESSMENT ENDPOINTS AND RISK QUESTIONS

Guild	Receptor of Potential Concern	Assessment Endpoint for BERA	Ecological Risk Questions
Invertebrates	Earthworm	Protection of soil invertebrate community from uptake and direct toxic effects on detritivore abundance, diversity, productivity from COPECs in soil.	Does exposure to COPECs in soil adversely affect the abundance, diversity, productivity, and function?
Benthos and zooplankton	Polychaetes	Protection of benthic and water-column invertebrate communities from uptake and direct toxic effects on abundance, diversity, and productivity from COPECs in sediment and surface water.	Does exposure to CPOECs in sediment and surface water adversely affect the abundance, diversity, productivity, and function?

TABLE 5

COPECS AND MEDIA RECOMMENDED FOR FURTHER EVALUATION IN THE WORK PLAN FOR THE BASELINE ECOLOGICAL RISK ASSESSMENT

MEDIA	ASSESSMENT ENDPOINT	CHEMICAL OF POTENTIAL ECOLOGICAL CONCERN
North Area Soil	Direct Toxicity to Soil Invertebrate	4,4'-DDT Aroclor-1254
Intracoastal Waterway Sediment	Direct Toxicity to Benthic Receptor	4,4'-DDT Acenaphthene Benzo(a)anthracene Chrysene Dibenz(a,h)anthracene Fluoranthene Fluorene Hexachlorobenzene Phenanthrene Pyrene LPAH HPAH Total PAH
Wetlands Sediment	Direct Toxicity to Benthic Receptor	2-Methylnaphthalene 4,4'-DDT Acenaphthene Acenaphthylene Anthracene Benzo(a)anthracene Benzo(a)pyrene Benzo(g,h,i)perylene Chrysene Dibenz(a,h)anthracene Endrin Aldehyde Endrin Ketone Fluoranthene Fluorene gamma-Chlordane Indeno(1,2,3-cd)pyrene Nickel Phenanthrene Pyrene LPAH HPAH Total PAHs
Wetlands Surface Water	Direct Toxicity to Aquatic Invertebrates	Dissolved Copper
Pond Sediment	Direct Toxicity to Benthic Receptor	4,4'-DDT

Notes:

PAH - polynuclear aromatic hydrocarbon LPAH - low-molecular weight PAH HPAH - high-molecular weight PAH

FIGURES

QUADRANGLE LOCATION

N

Scale in Feet

0 1000 2000

Source:
Base map taken from http://www.tnris.state.tx.us Freeport, Texas 7.5 min. U.S.G.S. quadrangle, 1974.

GULFCO MARINE MAINTENANCE
FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 1

SITE LOCATION MAP

PROJECT: 1352	BY: ZGK	REVISIONS
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EXPLANATION

Gulfco Marine Maintenance Site Boundary (approximate)

Lot Boundary (approximate)

N

Approx. Scale in Feet

0 125 250

Source of photo: H-GAC, Texas aerial photograph, 2006.

GULFCO MARINE MAINTENANCE

FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 2

SITE MAP

PROJECT: 1352	BY: ZGK	REVISIONS
DATE: MARCH, 2010	CHECKED: EFP	

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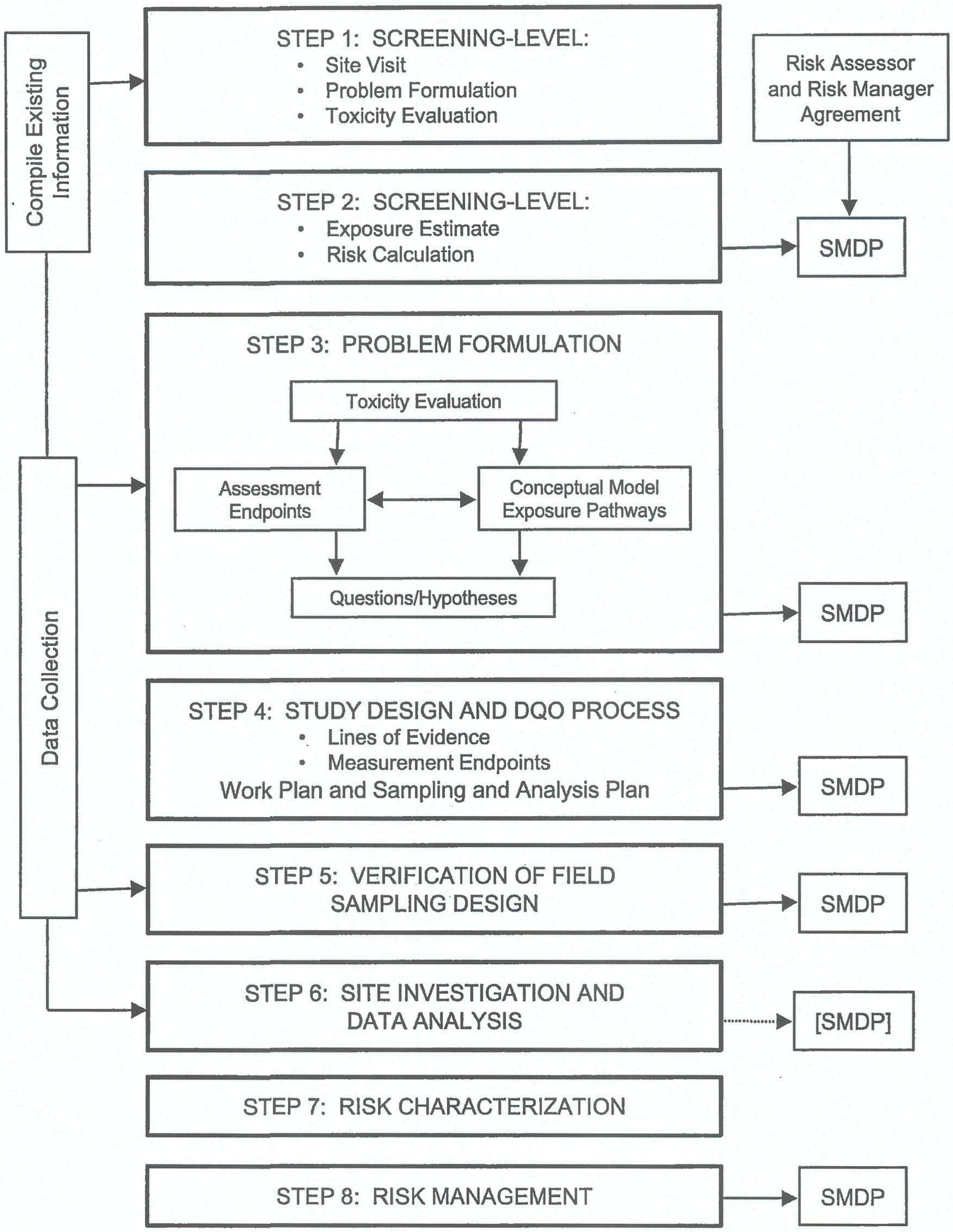

GULFCO MARINE MAINTENANCE
FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 3

ECOLOGICAL RISK ASSESSMENT PROCESS

PROJECT: 1352	BY: ZGK	REVISIONS
DATE: MARCH, 2010	CHECKED: EFP	

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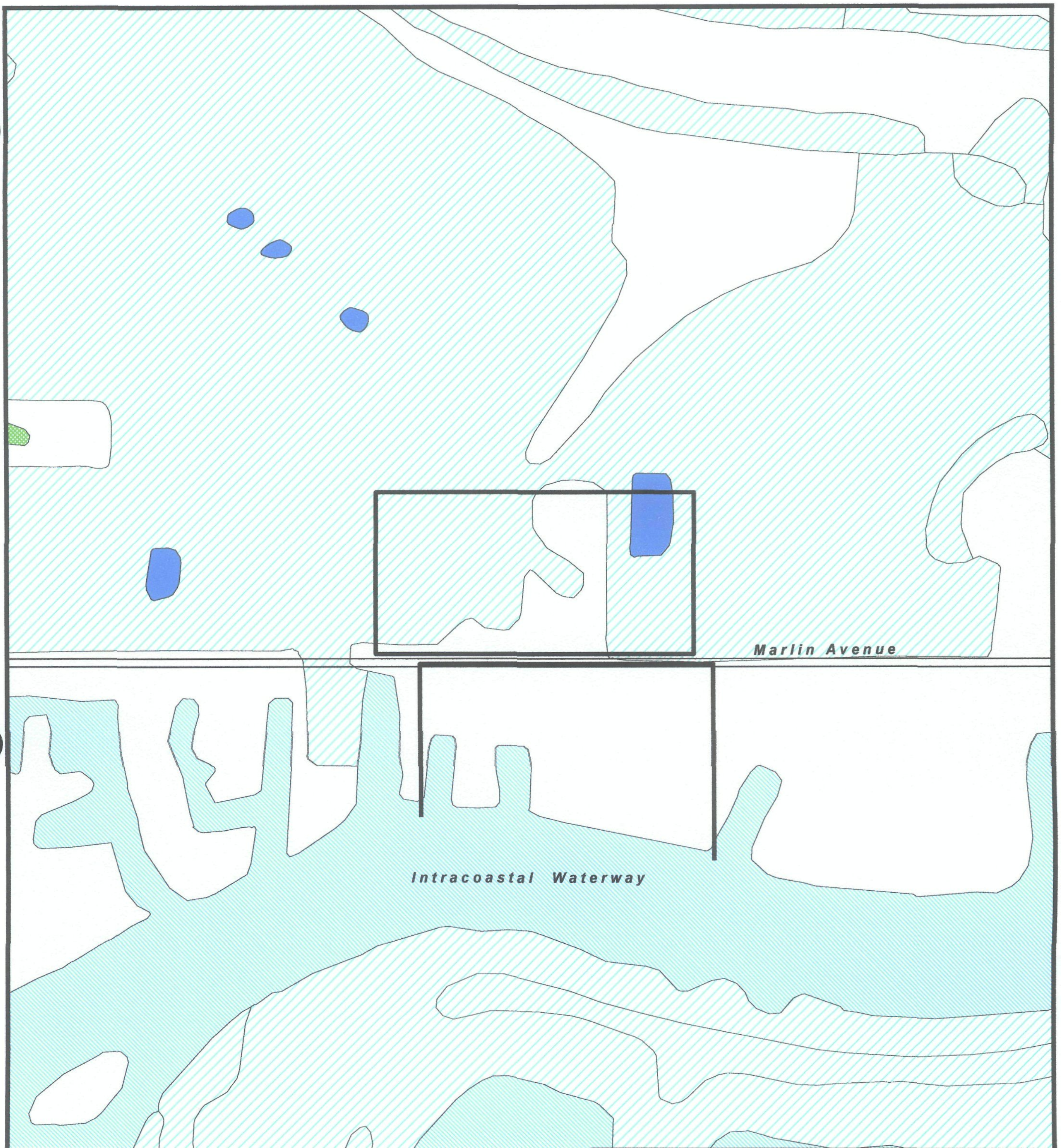
Source:
Exhibit I-2 from EPA Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, 1997.



EXPLANATION

- Approx. Site Boundary
- Upland Area
- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Pond

Approx. Scale in Feet

0 300 600

Source:
U.S. Fish & Wildlife Service, Wetlands Online Mapper, 2008.

GULFCO MARINE MAINTENANCE
FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 4

WETLAND MAP

PROJECT: 1352	BY: ZGK	REVISIONS
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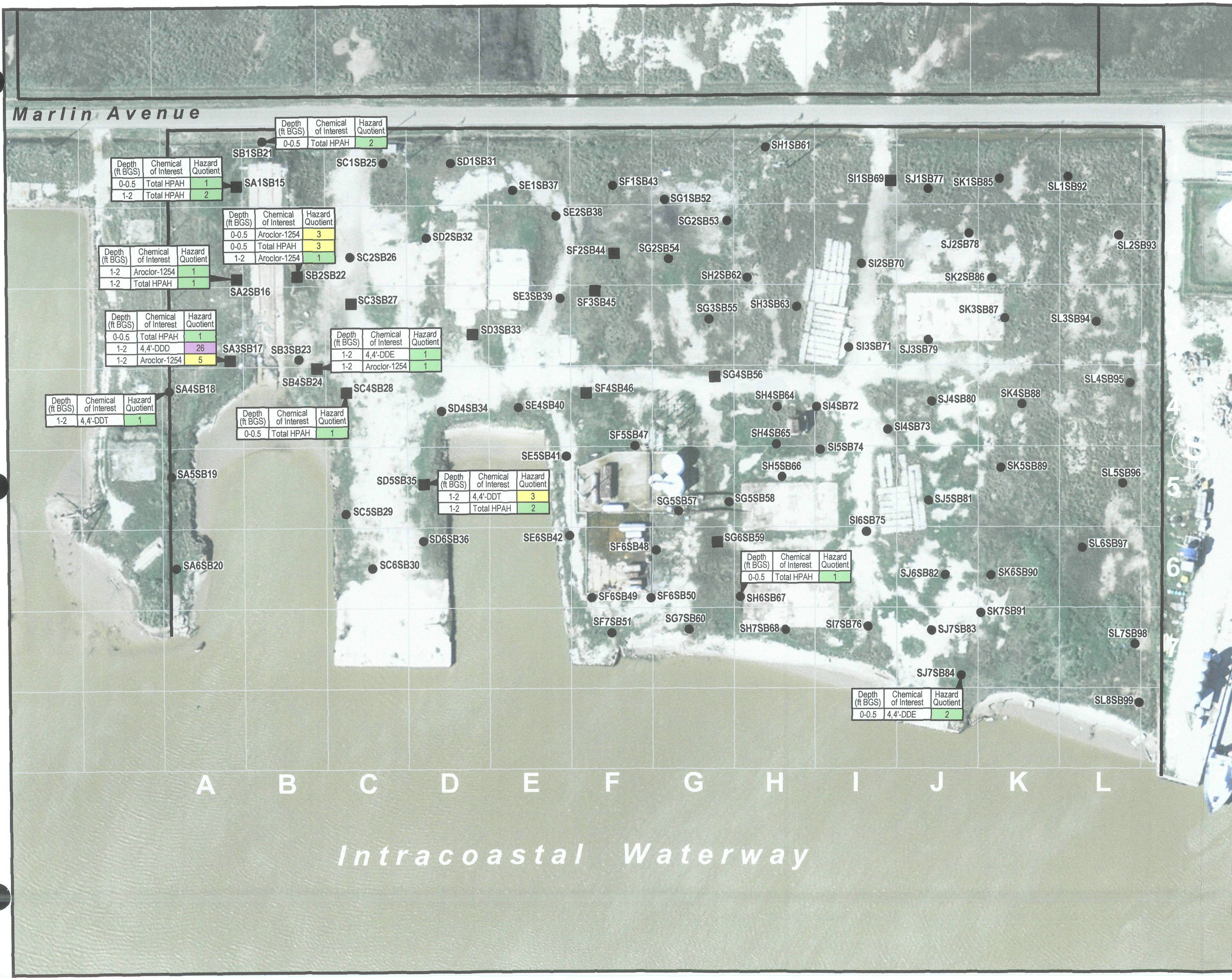

EXPLANATION

Gulfco Marine Maintenance Site Boundary (approximate)

● Shallow Soil Sample (0-2 ft)

■ Shallow (0-2 ft) and Deep (4-5 ft) Soil Sample

Notes:
1. BGS = below ground surface.
2. For sample concentration data, see SLERA Figures 6A through 6D.
* All Hazard Quotients for other receptors or compounds of concern were less than one. Hazard Quotients were based on No Observable Adverse Effects Level.

Hazard Quotients:
- > 1 and < 2
- > 2 and < 5
- > 5 but < 10
- > 10

N

Approx. Scale in Feet
0 60 120

Source of photo: H-GAC, Texas aerial photograph, 2006.

GULFCO MARINE MAINTENANCE
FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 5

HAZARD QUOTIENTS GREATER THAN ONE FOR SOIL INVERTEBRATES* - SOUTH AREA SOIL

PROJECT: 1352	BY: ZGK	REVISIONS
DATE: MARCH, 2010	CHECKED: KHT	

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EXPLANATION

Gulfco Marine Maintenance Site Boundary (approximate)

● Shallow (0-2 ft) Soil Sample

▲ Shallow (0-2 ft) and Deep (4+ ft) Soil Sample

☒ Geotechnical Soil Boring

Notes:
1. BGS = below ground surface.
2. For sample concentration data, see SLERA Figures 7A through 7B.
* All Hazard Quotients for other receptors or compounds of concern were less than one. Hazard Quotients were based on No Observable Adverse Effects Level.

Hazard Quotients:
- > 1 and ≤ 2
- > 2 and ≤ 5
- > 5 but ≤ 10
- > 10

Approx. Scale in Feet

0 60 120

Source of photo: H-GAC, Texas aerial photograph, 2006.

GULFCO MARINE MAINTENANCE
FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 6

HAZARD QUOTIENTS GREATER THAN ONE FOR SOIL INVERTEBRATES* - NORTH AREA SOIL

PROJECT: 1352	BY: ZGK	REVISIONS
DATE: MARCH, 2010	CHECKED: KHT	

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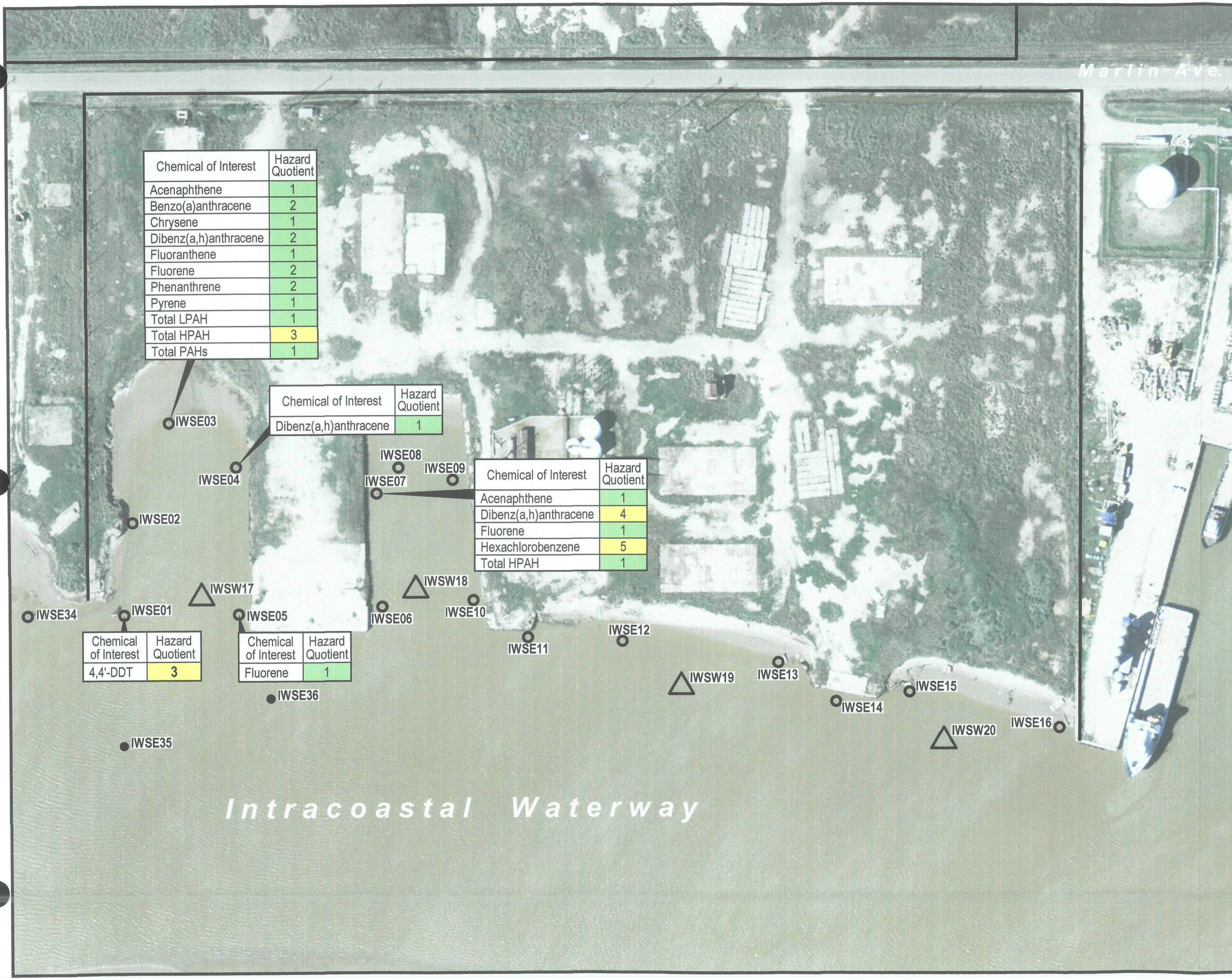

IWSE03:

Chemical of Interest	Hazard Quotient
Acenaphthene	1
Benzo(a)anthracene	2
Chrysene	1
Dibenz(a,h)anthracene	2
Fluoranthene	1
Fluorene	2
Phenanthrene	2
Pyrene	1
Total LPAH	1
Total HPAH	3
Total PAHs	1

IWSE04:

Chemical of Interest	Hazard Quotient
Dibenz(a,h)anthracene	1

IWSE07:

Chemical of Interest	Hazard Quotient
Acenaphthene	1
Dibenz(a,h)anthracene	4
Fluorene	1
Hexachlorobenzene	5
Total HPAH	1

IWSE01:

Chemical of Interest	Hazard Quotient
4,4'-DDT	3

IWSE05:

Chemical of Interest	Hazard Quotient
Fluorene	1

EXPLANATION

- Gulfco Marine Maintenance Site Boundary (approximate)
- Intracoastal Waterway Sediment Sample
- Intracoastal Waterway Surface Water Sample
- Attempted Intracoastal Waterway Sediment Sample (not enough sediment present to allow for sampling)

Notes:
1. For sample concentration data, see SLERA Figure 9.

* All Hazard Quotients for other receptors or compounds of concern were less than one. HQs for benthic receptors were based on the Effects Range Low except hexachlorobenzene which were based on the Apparent Effects Threshold.

Hazard Quotients:
- > 1 and ≤ 2
- > 2 and ≤ 5
- > 5 but ≤ 10
- > 10

N

Approx. Scale in Feet

0 60 120

Source of photo: H-GAC, Texas aerial photograph, 2006.

GULFCO MARINE MAINTENANCE
FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 7

HAZARD QUOTIENTS GREATER THAN ONE FOR BENTHIC RECEPTORS*- INTRACOASTAL WATERWAY SEDIMENT

PROJECT: 1352	BY: ZGK	REVISIONS
DATE: MARCH, 2010	CHECKED: KHT	

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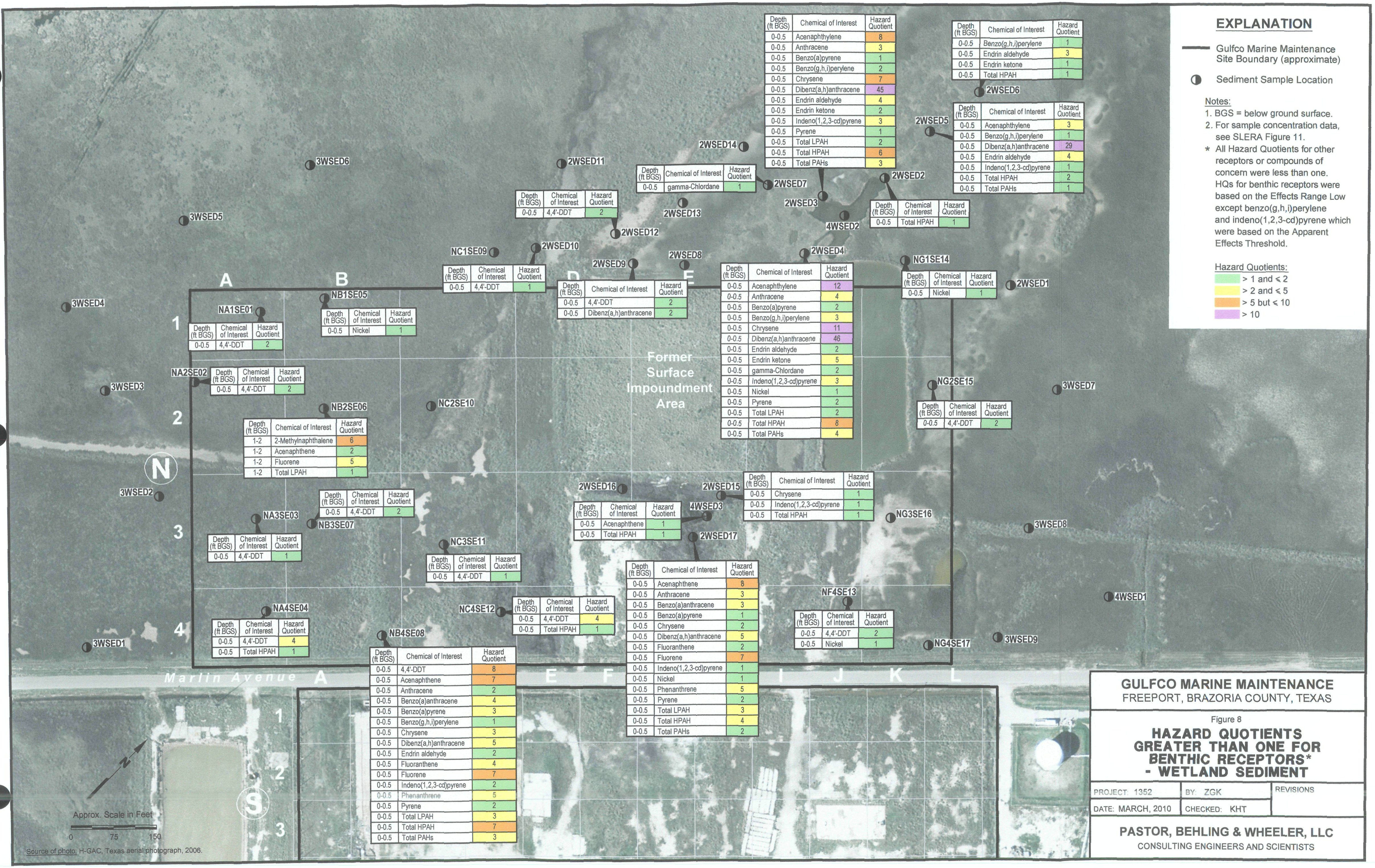

2WSED3

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	Acenaphthylene	8
0-0.5	Anthracene	3
0-0.5	Benzo(a)pyrene	1
0-0.5	Benzo(g,h,i)perylene	2
0-0.5	Chrysene	7
0-0.5	Dibenz(a,h)anthracene	45
0-0.5	Endrin aldehyde	4
0-0.5	Endrin ketone	2
0-0.5	Indeno(1,2,3-cd)pyrene	3
0-0.5	Pyrene	1
0-0.5	Total LPAH	2
0-0.5	Total HPAH	6
0-0.5	Total PAHs	3

2WSED6

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	Benzo(g,h,i)perylene	1
0-0.5	Endrin aldehyde	3
0-0.5	Endrin ketone	1
0-0.5	Total HPAH	1

2WSED5

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	Acenaphthylene	3
0-0.5	Benzo(g,h,i)perylene	1
0-0.5	Dibenz(a,h)anthracene	29
0-0.5	Endrin aldehyde	4
0-0.5	Indeno(1,2,3-cd)pyrene	1
0-0.5	Total HPAH	2
0-0.5	Total PAHs	1

2WSED7

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	gamma-Chlordane	1

2WSED2

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	Total HPAH	1

2WSED12

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	2

2WSED10

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	1

2WSED9

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	2
0-0.5	Dibenz(a,h)anthracene	2

2WSED4

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	Acenaphthylene	12
0-0.5	Anthracene	4
0-0.5	Benzo(a)pyrene	2
0-0.5	Benzo(g,h,i)perylene	3
0-0.5	Chrysene	11
0-0.5	Dibenz(a,h)anthracene	46
0-0.5	Endrin aldehyde	2
0-0.5	Endrin ketone	5
0-0.5	gamma-Chlordane	2
0-0.5	Indeno(1,2,3-cd)pyrene	3
0-0.5	Nickel	1
0-0.5	Pyrene	2
0-0.5	Total LPAH	2
0-0.5	Total HPAH	8
0-0.5	Total PAHs	4

NG1SE14

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	Nickel	1

NB1SE05

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	Nickel	1

NA1SE01

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	2

NA2SE02

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	2

NB2SE06

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
1-2	2-Methylnaphthalene	6
1-2	Acenaphthene	2
1-2	Fluorene	5
1-2	Total LPAH	1

NG2SE15

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	2

NB3SE07

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	2

NA3SE03

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	1

4WSED3

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	Acenaphthene	1
0-0.5	Total HPAH	1

2WSED15

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	Chrysene	1
0-0.5	Indeno(1,2,3-cd)pyrene	1
0-0.5	Total HPAH	1

NC3SE11

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	1

2WSED17

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	Acenaphthene	8
0-0.5	Anthracene	3
0-0.5	Benzo(a)anthracene	3
0-0.5	Benzo(a)pyrene	1
0-0.5	Chrysene	2
0-0.5	Dibenz(a,h)anthracene	5
0-0.5	Fluoranthene	2
0-0.5	Fluorene	7
0-0.5	Indeno(1,2,3-cd)pyrene	1
0-0.5	Nickel	1
0-0.5	Phenanthrene	5
0-0.5	Pyrene	2
0-0.5	Total LPAH	3
0-0.5	Total HPAH	4
0-0.5	Total PAHs	2

NC4SE12

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	4
0-0.5	Total HPAH	1

NF4SE13

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	2
0-0.5	Nickel	1

NA4SE04

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	4
0-0.5	Total HPAH	1

NB4SE08

Depth (ft BGS)	Chemical of Interest	Hazard Quotient
0-0.5	4,4'-DDT	8
0-0.5	Acenaphthene	7
0-0.5	Anthracene	2
0-0.5	Benzo(a)anthracene	4
0-0.5	Benzo(a)pyrene	3
0-0.5	Benzo(g,h,i)perylene	1
0-0.5	Chrysene	3
0-0.5	Dibenz(a,h)anthracene	5
0-0.5	Endrin aldehyde	2
0-0.5	Fluoranthene	4
0-0.5	Fluorene	7
0-0.5	Indeno(1,2,3-cd)pyrene	2
0-0.5	Phenanthrene	5
0-0.5	Pyrene	2
0-0.5	Total LPAH	3
0-0.5	Total HPAH	7
0-0.5	Total PAHs	3

EXPLANATION

Gulfco Marine Maintenance Site Boundary (approximate)

Sediment Sample Location

Notes:
1. BGS = below ground surface.
2. For sample concentration data, see SLERA Figure 11.
* All Hazard Quotients for other receptors or compounds of concern were less than one. HQs for benthic receptors were based on the Effects Range Low except benzo(g,h,i)perylene and indeno(1,2,3-cd)pyrene which were based on the Apparent Effects Threshold.

Hazard Quotients:
- > 1 and ≤ 2
- > 2 and ≤ 5
- > 5 but ≤ 10
- > 10

GULFCO MARINE MAINTENANCE
FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 8

HAZARD QUOTIENTS GREATER THAN ONE FOR BENTHIC RECEPTORS* - WETLAND SEDIMENT

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EXPLANATION

Gulfco Marine Maintenance Site Boundary (approximate)

Pond Sediment Sample Location

Notes:
1. For sample concentration data, see SLERA *Figure* 12.
* All Hazard Quotients for other receptors or compounds of concern were less than one. HQs *for benthic receptors* were based on the Effects Range Low.

Hazard Quotients:
- > 1 and ≤ 2
- > 2 and ≤ 5
- > 5 but ≤ 10
- > 10

N

Approx. Scale in Feet

0 60 120

Source of photo: H-GAC, Texas aerial photograph, 2006.

GULFCO MARINE MAINTENANCE
FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 9

HAZARD QUOTIENTS GREATER THAN ONE FOR BENTHIC RECEPTORS* - PONDS SEDIMENT

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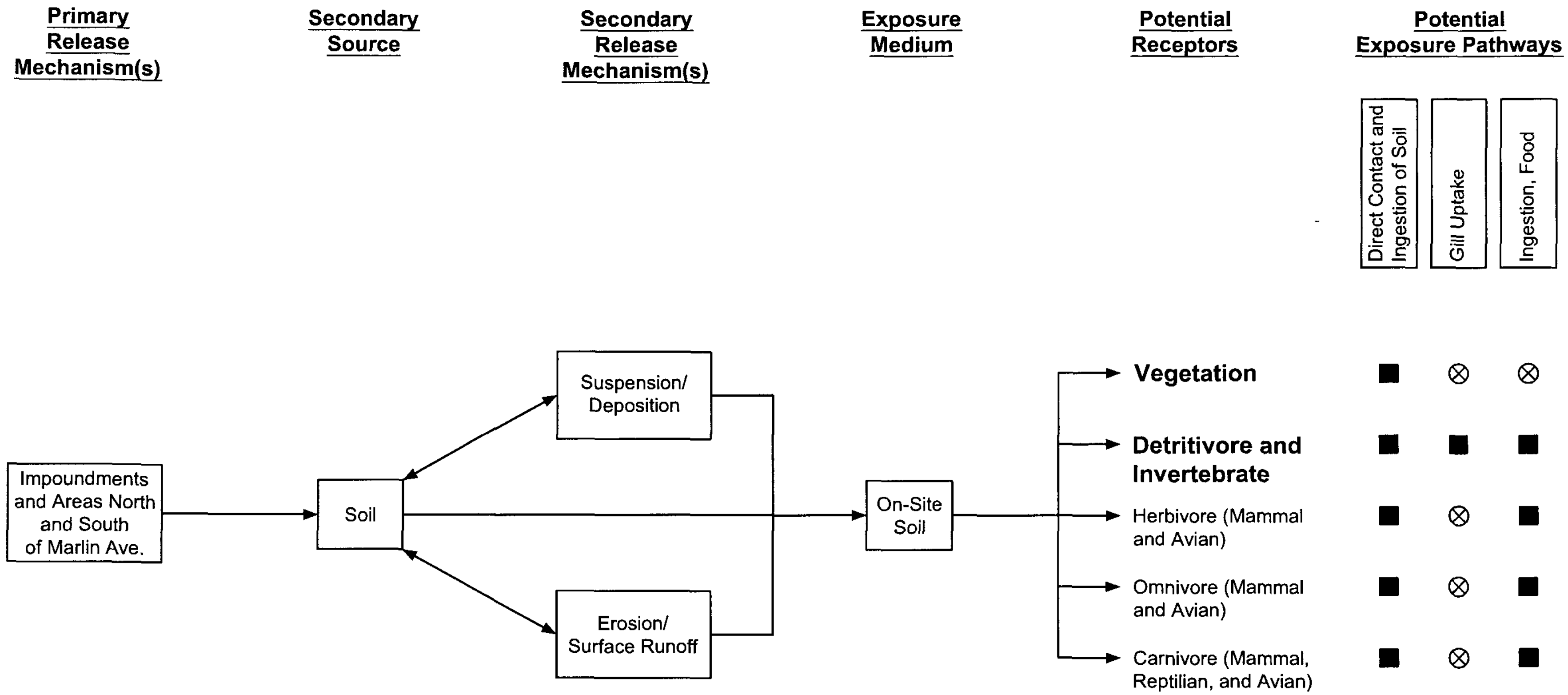

Potential Receptors	Direct Contact and Ingestion of Soil	Gill Uptake	Ingestion, Food
Vegetation	■	⊗	⊗
Detritivore and Invertebrate	■	■	■
Herbivore (Mammal and Avian)	■	⊗	■
Omnivore (Mammal and Avian)	■	⊗	■
Carnivore (Mammal, Reptilian, and Avian)	■	⊗	■

LEGEND

■ Pathway is potentially complete

⊠ Pathway is incomplete

⊗ Pathway is not viable

Note:
Significant Potential Receptors shown in bold.

GULFCO MARINE MAINTENANCE
FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 10

TERRESTRIAL ECOSYSTEM CONCEPTUAL SITE MODEL

PROJECT: 1352	BY: ZGK	REVISIONS
DATE: MARCH, 2010	CHECKED: KHT	

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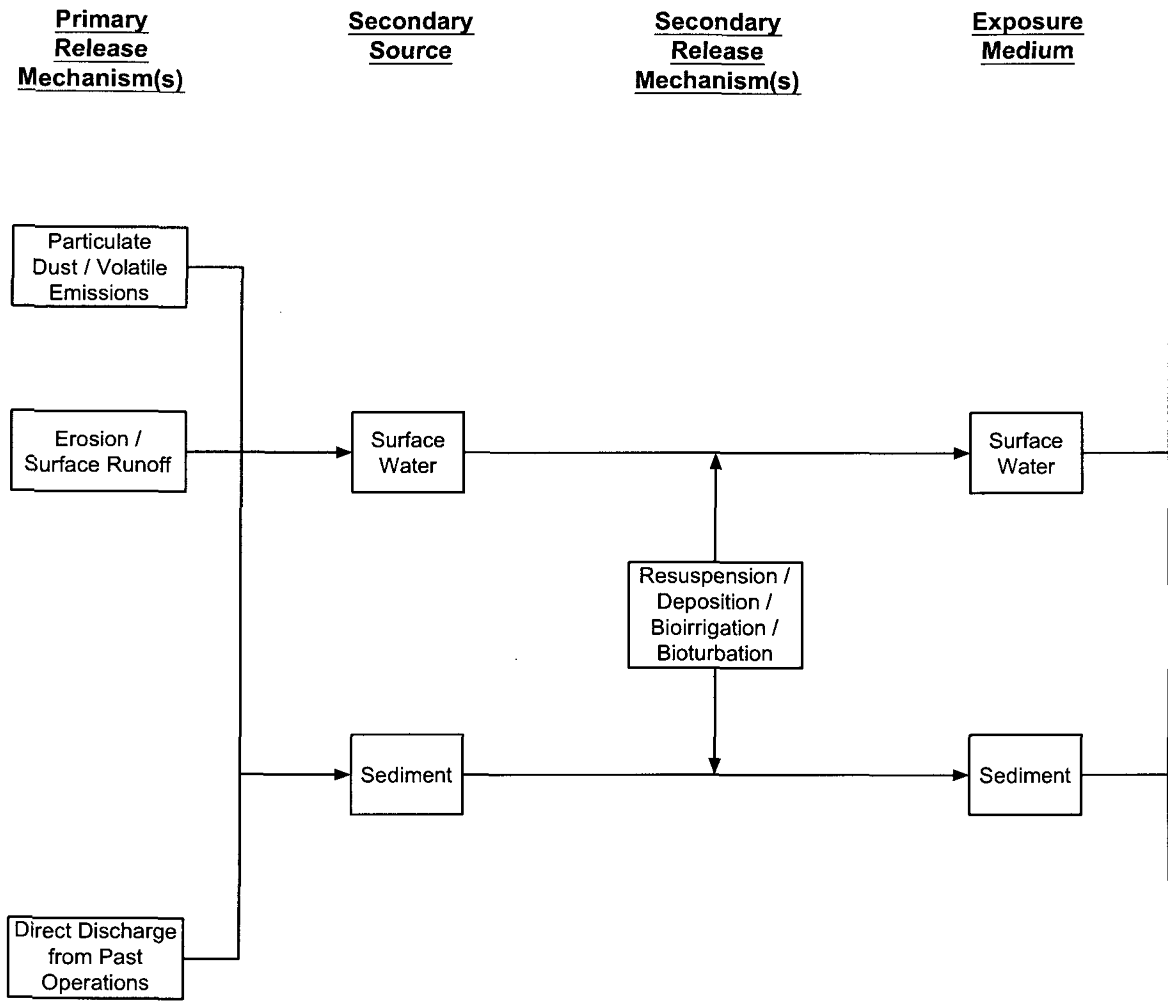

Exposure Medium	Potential Receptors	Direct Contact (a)	Gill Uptake	Ingestion, Food	Ingestion, Media
Surface Water	**Benthos/Epibenthos**	■	■	■	⊠
Surface Water	**Zooplankton**	■	■	■	⊠
Surface Water	Fish / Shellfish	■	■	■	■
Surface Water	Vertebrate Carnivore, Fish	■	■	■	⊠
Surface Water	Vertebrate Carnivore, Bird	■	⊗	■	⊠
Surface Water	Vegetation	■	⊗	⊗	⊗
Sediment	**Benthos/Epibenthos**	■	■	■	■
Sediment	Fish / Shellfish	■	⊗	■	■
Sediment	Vertebrate Carnivore, Fish	■	⊗	■	■
Sediment	Vertebrate Carnivore, Bird	■	⊗	■	■
Sediment	Vegetation	■	⊗	⊗	⊗

LEGEND

■ Pathway is potentially complete

⊠ Pathway is incomplete

⊗ Pathway is not viable

(a) Direct contact includes dermal absorption

Note:
Significant Potential Receptors shown in bold.

GULFCO MARINE MAINTENANCE
FREEPORT, BRAZORIA COUNTY, TEXAS

Figure 11

AQUATIC ECOSYSTEM CONCEPTUAL SITE MODEL

PROJECT: 1352	BY: ZGK	REVISIONS
DATE: MARCH, 2010	CHECKED: KHT	

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APPENDIX A

TABLE 29 (COPECS AND MEDIA RECOMMENDED FOR FURTHER EVALUATION IN THE BASELINE ECOLOGICAL RISK ASSESSMENT) FROM SLERA

TABLE 29

COPECS AND MEDIA RECOMMENDED FOR FURTHER EVALUATION IN THE BASELINE ECOLOGICAL RISK ASSESSMENT

MEDIA	ASSESSMENT ENDPOINT	CHEMICAL OF POTENTIAL ECOLOGICAL CONCERN
South Area Soil	Direct Toxicity to Soil Invertebrate	4,4'-DDD 4,4'-DDE 4,4'-DDT Aroclor-1254 Barium Chromium Copper Zinc Total HPAH
North Area Soil	Direct Toxicity to Soil Invertebrate	4,4'-DDT Aroclor-1254 Barium Chromium Copper Zinc
Intracoastal Waterway Sediment	Direct Toxicity to Benthic Receptor	4,4'-DDT Acenaphthene Benzo(a)anthracene Chrysene Dibenz(a,h)anthracene Fluoranthene Fluorene Hexachlorobenzene Phenanthrene Pyrene LPAH HPAH Total PAH
Wetlands Sediment	Direct Toxicity to Benthic Receptor	2-Methylnaphthalene 4,4'-DDT Acenaphthene Acenaphthylene Anthracene Arsenic Benzo(a)anthracene Benzo(a)pyrene Benzo(g,h,i)perylene Chrysene Copper Dibenz(a,h)anthracene Endrin Aldehyde Endrin Ketone Fluoranthene Fluorene gamma-Chlordane Indeno(1,2,3-cd)pyrene Lead Nickel Phenanthrene Pyrene Zinc LPAH HPAH Total PAHs
Wetlands Surface Water	Direct Toxicity to Aquatic Invertebrate	Acrolein Copper
Pond Sediment	Direct Toxicity to Benthic Receptor	4,4'-DDT Zinc
Pond Sediment and Surface Water	Food Chain (Ingestion) Effects for the Avian Carnivore (Sandpiper)	Lead
Pond Surface Water	Direct Toxicity to Aquatic Invertebrate	Silver

Notes:
PAH - polynuclear aromatic hydrocarbon
LPAH - low-molecular weight PAH
HPAH - high-molecular weight PAH

APPENDIX B
BACKGROUND COMPARISONS

APPENDIX B
TABLE 1
BACKGROUND COMPARISONS

HYPOTHESIS TESTED: SITE METAL CONCENTRATIONS ARE NOT STATISTICALLY DIFFERENT FROM BACKGROUND METAL CONCENTRATIONS [1]					
COPECs	**SOUTH SOIL[2]**	**NORTH SOIL[3]**	**ICWW SEDIMENT**	**WETLANDS SEDIMENT**	**POND SEDIMENT**
Barium	True	False*	-	-	-
Chromium	True	True	-	-	-
Copper	True	True	-	True	-
Lead	-	-	-	True	-
Zinc	True	True	-	True	True

Notes:
(1) Discussed in Section 2.2 and calculations are provided in Appendix B.
(2) Includes data for all South Area soil samples from surface to 2 feet below ground surface.
(3) Includes data for all North Area soil samples from surface to 2 feet below ground surface.
- COPEC was dismissed because HQ<1 in SLERA or after refinement described in Section 2.1.
* Statistical difference is due to background being greater than site.

Conclusion: All metal COPECs in soil dismissed from further evaluation after statistical comparison to background concentrations.

APPENDIX B-1
BACKGROUND COMPARISONS

SOUTH OF MARLIN SOIL

BARIUM - SOUTH OF MARLIN SOIL						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Barium	237.4	274.8	166	333.1	288.1	10

Calculated Difference =	95.7	
Standard Error of the Difference =	112.8814519	
Degree of Freedom =	174	
t =	0.847792072	
p =	0.1989	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	site soil mean is not statistically less than background mean

CHROMIUM - SOUTH OF MARLIN SOIL						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Chromium	13.53	12.49	166	15.2	3.02	10

Calculated Difference =	1.67	
Standard Error of the Difference =	3.176242508	
Degree of Freedom =	174	
t =	0.525778493	
p =	0.2998	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	site soil mean is not statistically less than background mean

COPPER - SOUTH OF MARLIN SOIL						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Copper	24.26	46.76	166	12.12	3.955	10

Calculated Difference = 12.14
Standard Error of the Difference = 11.40971991
Degree of Freedom = 174
t = 1.064005085
p = 0.1444 calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different = No site soil mean is not statistically greater than background mean

ZINC - SOUTH OF MARLIN SOIL						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Zinc	433.8	786.8	166	247	364.6	10

Calculated Difference =	186.8	
Standard Error of the Difference =	222.9535182	
Degree of Freedom =	174	
t =	0.8378428	
p =	0.2016	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	*site soil mean is not statistically greater than background mean*

APPENDIX B-2
BACKGROUND COMPARISONS

NORTH OF MARLIN SOIL

BARIUM - NORTH OF MARLIN SOIL						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Barium	142.1	95.9	36	333.1	288.1	10

Calculated Difference =	191	
Standard Error of the Difference =	94.02738869	
Degree of Freedom =	44	
t =	2.031323029	
p =	0.0242	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	Yes	site surface soil mean is statistically less than background mean

CHROMIUM - NORTH OF MARLIN SOIL						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Chromium	17.17	19.6	36	15.2	3.02	10

Calculated Difference =	1.97	
Standard Error of the Difference =	4.848678898	
Degree of Freedom =	44	
t =	0.406296239	
p =	0.3432	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	site soil mean is not statistically greater than background mean

COPPER - NORTH OF MARLIN SOIL						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Copper	18.7	31.9	36	12.12	3.955	10

Calculated Difference =	6.58	
Standard Error of the Difference =	7.837321881	
Degree of Freedom =	44	
t =	0.83957251	
p =	0.2028	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	site soil mean is not statistically greater than background mean

ZINC - NORTH OF MARLIN SOIL						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Zinc	242.5	929.4	36	247	364.6	10

Calculated Difference =	4.5	
Standard Error of the Difference =	253.1879948	
Degree of Freedom =	44	
t =	0.017773355	
p =	0.4929	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	site soil mean is not statistically less than background mean

APPENDIX B-3
BACKGROUND COMPARISONS

WETLAND SEDIMENT

ARSENIC - WETLAND SEDIMENT						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Arsenic	2.534	2.465	48	3.438	1.792	10

Calculated Difference =	0.904	
Standard Error of the Difference =	0.823742314	
Degree of Freedom =	56	
t =	1.097430573	
p =	0.1387	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	site soil mean is not statistically less than background mean

COPPER - WETLAND SEDIMENT						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Copper	14.49	8.49	48	12.12	3.955	10

Calculated Difference =	2.37	
Standard Error of the Difference =	2.409192475	
Degree of Freedom =	56	
t =	0.983732111	
p =	0.1647	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	site soil mean is not statistically greater than background mean

LEAD - WETLAND SEDIMENT						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Lead	25.36	34.13	48	13.43	1.547	10

Calculated Difference =	11.93	
Standard Error of the Difference =	8.292183972	
Degree of Freedom =	56	
t =	1.438704211	
p =	0.0779	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	site surface soil mean is not statistically greater than background mean

ZINC - WETLAND SEDIMENT						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Zinc	139.1	160.9	53	247	364.6	10

Calculated Difference =	107.9	
Standard Error of the Difference =	121.7217613	
Degree of Freedom =	61	
t =	0.886447902	
p =	0.1896	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	site soil mean is not statistically less than background mean

APPENDIX B-4
BACKGROUND COMPARISONS

POND SEDIMENT

ZINC - POND SEDIMENT						
Compound	Site Conc. Mean	Site Conc. Standard Deviation	Number of Site Samples	Background Conc. Mean	Background Conc. Standard Deviation	Number of Background Samples
Zinc	332.3	407.7	8	247	364.6	10

Calculated Difference =	85.3	
Standard Error of the Difference =	151.8911495	
Degree of Freedom =	16	
t =	0.561586375	
p =	0.2910	calculated at www.stat.tamu.edu/~west/applets/tdemo.html
Data sets significantly different =	No	site soil mean is not statistically greater than background mean

APPENDIX C

ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOUTH AREA SOIL

TABLE C-1
EXPOSURE POINT CONCENTATION (mg/kg)
SOIL SOUTH OF MARLIN AVE.*

Parameter	Exposure Point Concentration	Statistic Used
4,4-DDD	5.08E-02	97.5% KM (Chebyshev)
4,4'-DDE	2.81E-03	95% KM (BCA)
4,4'-DDT	9.27E-03	97.5% KM (Chebyshev)
Aroclor-1254	7.73E-01	97.5% KM (Chebyshev)
Barium	3.30E+02	95% Chebyshev
Chromium	1.78E+01	95% Chebyshev
Copper	4.01E+01	95% KM (Chebyshev)
Zinc	8.15E+02	97.5% Chebyshev
TOTAL PAHs	8.61E+00	

Notes:
* Soil data includes soil collected from 0 to 2 feet below ground surface.

TABLE C-2
EXPOSURE POINT CONCENTATION (mg/kg)
SURFACE SOIL SOUTH OF MARLIN AVE.*

Parameter	95% UCL	Statistic Used
4,4'-DDD	< 2.70E-04	median
4,4'-DDE	7.52E-03	97.5% KM (Chebyshev)
4,4'-DDT	1.03E-02	97.5% KM (Chebyshev)
Aroclor-1254	7.64E-01	97.5% KM (Chebyshev)
Barium	5.84E+02	97.5% KM (Chebyshev)
Chromium	2.68E+01	97.5% Chebyshev
Copper	5.22E+01	97.5% KM (Chebyshev)
Zinc	1.06E+03	97.5% Chebyshev
TOTAL PAHs	1.06E+04	

Notes:
NS - Not sampled in surface soil.
* Surface soil data includes soil collected from 0 to 0.5 feet below ground surface.

TABLE C-3
TOXICITY VALUES

Parameter	Invertebrate (Earthworm) (mg/kg)	Ref.	Comments	Small Mammalian Herbivore (Deer Mouse) (mg/kgBW-day)	Ref.	Comments	Large Mammalian Carnivore (Coyote) (mg/kgBW-day)	Ref.	Comments	Small Mammalian Omnivore (Least Shrew) (mg/kgBW-day)	Ref.	Comments	Avian Herbivore/Omnivore (American Robin) (mg/kgBW-day)	Ref.	Comments	Large Avian Carnivore (Red-tailed Hawk) (mg/kgBW-day)	Ref.	Comments
4,4-DDD	4.30E-02	EPA, 2007a	Acute median LC50 in common cricket (dose 4.3 with uncertainty factor of 0.01)	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
4,4'-DDE	4.30E-02	EPA, 2007a	Acute median LC50 in common cricket (dose 4.3 with uncertainty factor of 0.01)	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
4,4'-DDT	4.30E-02	EPA, 2007a	Acute median LC50 in common cricket (dose 4.3 with uncertainty factor of 0.01)	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
Aroclor-1254	2.51E+00	EPA, 1999	Acute median LC50 in earthworms (dose 251 with uncertainty factor of 0.01)	1.55E-01	Sample, 1996	Chronic LOAEL for reproduction in mouse with an uncertainty factor of 0.1	1.55E-01	Sample, 1996	Chronic LOAEL for reproduction in mouse with an uncertainty factor of 0.1	1.55E-01	Sample, 1996	Chronic LOAEL for reproduction in mouse with an uncertainty factor of 0.1	1.80E-01	Sample, 1996		1.80E-01	Sample, 1996	
Barium	3.30E+02	EPA, 2005g	Geometric mean of the EC20 values for three test species under three separate test conditions of pH	5.18E+01	EPA, 2005g	Geometric mean of NOAEL values for reproduction and growth	4.10E-01	EPA, 1999		5.18E+01	EPA, 2005g	Geometric mean of NOAEL values for reproduction and growth	1.91E+01	EPA, 1999		3.15E+01	EPA, 1999	
Chromium	5.70E+01	EPA, 2005c	Maximum acceptable toxicant concentration (MATC) for reproductive effects in earthworm	2.40E+00	EPA, 2005c	Geometric mean of NOAEL values for reproduction and growth	2.40E+00	EPA, 2005c	Geometric mean of NOAEL values for reproduction and growth	2.40E+00	EPA, 2005c	Geometric mean of NOAEL values for reproduction and growth	2.66E+00	EPA, 2005c	Geometric mean of the NOAEL values for reproduction and growth	2.66E+00	EPA, 2005c	Geometric mean of the NOAEL values for reproduction and growth
Copper	8.00E+01	EPA, 2007c	Geometric mean of the MATC and EC10 values for six test species under different test species	5.60E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	5.60E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	5.60E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	4.05E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	4.05E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
Zinc	1.20E+02	EPA, 2007e	Geometric mean of the MATC and EC10 values for three test species under different test species	7.54E+01	EPA, 2007e	Geometric mean of NOAEL values for reproduction and growth	7.54E+01	EPA, 2007e	Geometric mean of NOAEL values for reproduction and growth	7.54E+01	EPA, 2007e	Geometric mean of NOAEL values for reproduction and growth	6.61E+01	EPA, 2007e	Geometric mean of NOAEL values within the reproductive and growth effect groups	6.61E+01	EPA, 2007e	Geometric mean of NOAEL values within the reproductive and growth effect groups
TOTAL PAHs																		

Notes:

EPA, 2007a -- DDT
EPA, 2007b -- PAHs
EPA, 2007c -- Copper
EPA, 2007e -- Zinc
EPA, 2005c -- Chromium
EPA, 2005g -- Barium

TABLE C-4
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL SOUTH OF MARLIN
Invertebrate (EARTHWORM)

Ecological Hazard Quotient = Sc/TRV

Parameter	Definition	Default
Sc	Soil Concentration (mg/kg)	see below
TRV	Toxicity Reference Value (mg/kg)	see Table C-3

Chemical	Exposure Point Concentration* Sc	TRV Invertebrate (Earthworm)	Maximum EHQ⁺
4,4-DDD	1.12E+00	4.30E-02	2.60E+01
4,4'-DDE	6.93E-02	4.30E-02	1.61E+00
4,4'-DDT	1.13E-01	4.30E-02	2.63E+00
Aroclor-1254	1.15E+01	2.51E+00	4.58E+00
Barium	2.18E+03	3.30E+02	6.61E+00
Chromium	1.36E+02	5.70E+01	2.39E+00
Copper	4.87E+02	8.00E+01	6.09E+00
Zinc	7.65E+03	1.20E+02	6.38E+01
TOTAL PAHs	7.48E+01		

Notes:
*EPC for sedentary receptor is maximum measured concentration.
⁺Shading indicates HQ > 1.

TABLE C-5
INTAKE CALCULATIONS FOR SOIL SOUTH OF MARLIN
Small Mammalian Herbivore (DEER MOUSE)

SOIL INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Soil concentration (mg/kg)	See Table C-1	
IR	Maximum Ingestion rate of soil (kg/day)*	1.50E-06	EPA, 1993
IR_{max}	Mean Ingestion rate of soil (kg/day)*	1.50E-06	EPA, 1993
AF	Chemical Bioavailability in soil (unitless)	1	EPA, 1997
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	1.50E+02	Davis and Schmidly, 2009
Bw_{mean}	Mean Body weight (kg)	2.35E-02	Davis and Schmidly, 2009

Chemical	Sc	Intake	Refined Intake
4,4-DDD	5.08E-02	5.08E-10	3.24E-06
4,4'-DDE	2.81E-03	2.81E-11	1.79E-07
4,4'-DDT	9.27E-03	9.27E-11	5.92E-07
Aroclor-1254	7.73E-01	7.73E-09	4.93E-05
Barium	3.30E+02	3.30E-06	2.11E-02
Chromium	1.78E+01	1.78E-07	1.13E-03
Copper	4.01E+01	4.01E-07	2.56E-03
Zinc	8.15E+02	8.15E-06	5.20E-02
TOTAL PAHs	8.61E+00	8.61E-08	5.50E-04

FOOD INGESTION

INTAKE = ((Ca * IR * DFa * AUF) / (BW) + ((Cp * IR * DFs *AUF)/(BW))

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Ca	Arthropod concentration (mg/kg)	see Table C-15	
Cp	Plant concentration (mg/kg)	see Table C-15	
IR	Maximum Ingestion rate of of food (kg/day)*	7.49E-05	EPA, 1993
IR_{max}	Mean Ingestion rate of of food (kg/day)*	7.49E-05	EPA, 1993
Dfa	Dietary fraction of arthropods (unitless)	1.00E-01	Prof Judgment
Dfs	Dietary fraction of plants, seeds and other vegetation (unitless)	9.00E-01	Prof Judgment
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	1.50E-02	Davis and Schmidly, 2009
Bw_{mean}	Mean Body weight (kg)	2.35E-02	Davis and Schmidly, 2009

Chemical	Arthropod	Plant	Intake	Refined Intake
4,4-DDD	6.40E-02	4.76E-04	3.41E-05	2.18E-05
4,4'-DDE	3.54E-03	2.63E-05	1.89E-06	1.20E-06
4,4'-DDT	1.17E-02	8.69E-05	6.22E-06	3.97E-06
Aroclor-1254	8.73E-01	7.73E-03	4.71E-04	3.01E-04
Barium	7.27E+01	4.96E+01	2.59E-01	1.65E-01
Chromium	1.78E-01	1.33E-01	6.87E-04	4.38E-04
Copper	1.60E+00	1.60E+01	7.28E-02	4.65E-02
Zinc	4.57E+02	9.78E-10	2.28E-01	1.46E-01
TOTAL PAHs	6.03E-01	1.72E-01	1.08E-03	6.86E-04

TOTAL INTAKE

INTAKE = Soil Intake + Food Intake

Chemical	Total Intake	Refined Intake
4,4-DDD	3.41E-05	2.50E-05
4,4'-DDE	1.89E-06	1.38E-06
4,4'-DDT	6.22E-06	4.56E-06
Aroclor-1254	4.71E-04	3.50E-04
Barium	2.59E-01	1.86E-01
Chromium	6.87E-04	1.57E-03
Copper	7.28E-02	4.91E-02
Zinc	2.28E-01	1.98E-01
TOTAL PAHs	1.08E-03	1.24E-03

Notes:
* Expressed in dry weight.

TABLE C-6
INTAKE CALCULATIONS FOR SOIL SOUTH OF MARLIN
Large Mammalian Carnivore (COYOTE)

SOIL INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Soil concentration (mg/kg)	see Table C-1	
IR	Maximum Ingestion rate of soil (kg/day)*	4.83E-05	EPA, 1993
IR_{max}	Mean Ingestion rate of soil (kg/day)*	4.83E-05	EPA, 1993
AF	Chemical Bioavailability in soil (unitless)	1	EPA, 1997
AUF	Area Use Factor	1	EPA, 1997
AUF	Area Use Factor - Refined	5.75E-03	Sample et al., 1997
BW	Minimum Body weight (kg)	1.40E+01	Davis and Schmidly, 2009
Bw_{mean}	Mean Body weight (kg)	1.70E+01	Davis and Schmidly, 2009

Chemical	Sc	Intake	Refined Intake
4,4-DDD	5.08E-02	1.75E-07	8.30E-10
4,4'-DDE	2.81E-03	9.69E-09	4.59E-11
4,4'-DDT	9.27E-03	3.20E-08	1.51E-10
Aroclor-1254	7.73E-01	2.67E-06	1.26E-08
Barium	3.30E+02	1.14E-03	5.40E-06
Chromium	1.78E+01	6.12E-05	2.90E-07
Copper	4.01E+01	1.38E-04	6.55E-07
Zinc	8.15E+02	2.81E-03	1.33E-05
TOTAL PAHs	8.61E+00	2.97E-05	1.41E-07

FOOD INGESTION

INTAKE = ((Cm * IR * Dfm * AUF)/(BW) + (Cb * IR * DFb * AUF) / (BW))

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Cm	Mammal concentration (mg/kg)	see Table C-15	
Cb	Bird concentration (mg/kg)	see Table C-15	
IR	Maximum Ingestion rate of of food (kg/day)*	2.41E-03	EPA, 1993
IR_{max}	Mean Ingestion rate of of food (kg/day)*	2.41E-03	EPA, 1993
Dfm	Dietary fraction of small mammals (unitless)	7.50E-01	EPA, 1993
Dfb	Dietary fraction of birds (unitless)	2.50E-01	EPA, 1993
AUF	Area Use Factor	1	EPA, 1997
AUF	Area Use Factor - Refined	5.75E-03	Sample et al., 1997
BW	Minimum Body weight (kg)	1.40E+01	EPA, 1993
Bw_{mean}	Mean Body weight (kg)	1.70E+01	Davis and Schmidly, 2009

Chemical	Mammal	Bird	Intake	Refined Intake
4,4-DDD	1.63E-05	3.35E-05	3.54E-09	9.94E-12
4,4'-DDE	8.99E-07	1.85E-06	1.96E-10	5.50E-13
4,4'-DDT	2.97E-06	6.11E-06	6.46E-10	1.81E-12
Aroclor-1254	2.33E-04	4.61E-04	4.99E-08	1.42E-10
Barium	4.53E-03	4.53E-03	7.79E-07	2.77E-09
Chromium	5.80E-04	5.80E-04	9.98E-08	3.54E-10
Copper	1.81E+01	1.81E+01	3.12E-03	1.11E-05
Zinc	1.05E-04	1.02E-01	4.40E-06	6.43E-11
TOTAL PAHs	1.02E-02	1.40E-02	1.92E-06	6.26E-09

TOTAL INTAKE

INTAKE = Soil Intake + Food Intake

Chemical	Total Intake	Refined Intake
4,4-DDD	1.79E-07	8.40E-10
4,4'-DDE	9.89E-09	4.65E-11
4,4'-DDT	3.26E-08	1.53E-10
Aroclor-1254	2.72E-06	1.28E-08
Barium	1.14E-03	5.40E-06
Chromium	6.13E-05	2.90E-07
Copper	3.26E-03	1.17E-05
Zinc	2.82E-03	1.33E-05
TOTAL PAHs	3.16E-05	1.47E-07

Notes:
* Expressed in dry weight.

TABLE C-7
INTAKE CALCULATIONS FOR SOIL SOUTH OF MARLIN
Small Mammalian Omnivore (LEAST SHREW)

SOIL INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Soil concentration (mg/kg)	see Table C-1	
IR	Maximum Ingestion rate of soil (kg/day)*	2.71E-07	EPA, 1993
IR_{max}	Mean Ingestion rate of soil (kg/day)*	2.71E-07	EPA, 1993
AF	Chemical Bioavailability in soil (unitless)	1	EPA, 1997
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	4.00E-03	Davis and Schmidly, 2009
Bw_{mean}	Mean Body weight (kg)	5.75E-03	Davis and Schmidly, 2009

Chemical	Sc	Intake	Refined Intake
4,4-DDD	5.08E-02	3.44E-06	2.39E-06
4,4'-DDE	2.81E-03	1.90E-07	1.32E-07
4,4'-DDT	9.27E-03	6.28E-07	4.37E-07
Aroclor-1254	7.73E-01	5.24E-05	3.64E-05
Barium	3.30E+02	2.24E-02	1.56E-02
Chromium	1.78E+01	1.20E-03	8.37E-04
Copper	4.01E+01	2.72E-03	1.89E-03
Zinc	8.15E+02	5.52E-02	3.84E-02
TOTAL PAHs	8.61E+00	5.84E-04	4.06E-04

FOOD INGESTION

INTAKE = ((Ca * IR * DFa * AUF) / (BW) + ((Cp * IR * DFs *AUF)/(BW))

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Ca	Arthropod concentration (mg/kg)	see Table C-15	
Cp	Plant concentration (mg/kg)	see Table C-15	
IR	Maximum Ingestion rate of of food (kg/day)*	3.38E-06	EPA, 1993
IR_{max}	Mean Ingestion rate of of food (kg/day)*	3.38E-06	EPA, 1993
Dfa	Dietary fraction of arthropods (unitless)	9.00E-01	EPA, 1993
Dfs	Dietary fraction of plants, seeds and other vegetation (unitless)	1.00E-01	EPA, 1993
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	4.00E-03	Davis and Schmidly, 2009
Bw_{mean}	Mean Body weight (kg)	5.75E-03	Davis and Schmidly, 2009

Chemical	Arthropod	Plant	Intake	Refined Intake
4,4-DDD	6.40E-02	4.76E-04	4.87E-05	3.39E-05
4,4'-DDE	3.54E-03	2.63E-05	2.69E-06	1.87E-06
4,4'-DDT	1.17E-02	8.69E-05	8.89E-06	6.18E-06
Aroclor-1254	8.73E-01	7.73E-03	6.65E-04	4.63E-04
Barium	7.27E+01	4.96E+01	5.95E-02	4.14E-02
Chromium	1.78E-01	1.33E-01	1.46E-04	1.02E-04
Copper	1.60E+00	1.60E+01	2.57E-03	1.79E-03
Zinc	4.57E+02	9.78E-10	3.47E-01	2.42E-01
TOTAL PAHs	6.03E-01	1.72E-01	4.73E-04	3.29E-04

TOTAL INTAKE

INTAKE = Soil Intake + Food Intake

Chemical	Total Intake	Refined Intake
4,4-DDD	5.22E-05	3.63E-05
4,4'-DDE	2.89E-06	2.01E-06
4,4'-DDT	9.52E-06	6.62E-06
Aroclor-1254	7.17E-04	4.99E-04
Barium	8.19E-02	5.69E-02
Chromium	1.35E-03	9.38E-04
Copper	5.29E-03	3.68E-03
Zinc	4.02E-01	2.80E-01
TOTAL PAHs	1.06E-03	7.35E-04

Notes:
Soil ingestion was assumed to be 8% of dietary intake.
* Expressed in dry weight.

TABLE C-8
INTAKE CALCULATIONS FOR SOIL SOUTH OF MARLIN
Avian Omnivore/Herbivore (AMERICAN ROBIN)

SOIL INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Soil concentration (mg/kg)	see Table C-2	
IR	Maximum Ingestion rate of soil (kg/day)*	2.52E-06	EPA, 1993
IR_{max}	Mean Ingestion rate of soil (kg/day)*	2.52E-06	EPA, 1993
AF	Chemical Bioavailability in soil (unitless)	1	EPA, 1997
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	6.30E-02	EPA, 1993
Bw_{mean}	Mean Body weight (kg)	8.40E-02	EPA, 1993

Chemical	Sc	Intake	Refined Intake
4,4-DDD	2.70E-04	1.08E-08	8.10E-09
4,4'-DDE	7.52E-03	3.01E-07	2.26E-07
4,4'-DDT	1.03E-02	4.12E-07	3.09E-07
Aroclor-1254	7.64E-01	3.06E-05	2.29E-05
Barium	5.84E+02	2.34E-02	1.75E-02
Chromium	2.68E+01	1.07E-03	8.05E-04
Copper	5.22E+01	2.09E-03	1.57E-03
Zinc	1.06E+03	4.25E-02	3.19E-02
TOTAL PAHs	1.06E+04	4.23E-01	3.18E-01

FOOD INGESTION

INTAKE = ((Ce * IR * Dfe * AUF)/(BW) + (Ca * IR * DFa * AUF) / (BW) + ((Cp * IR * DFs *AUF)/(BW))

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Ce	Earthworm concentration (mg/kg)	see Table C-15	
Ca	Arthropod concentration (mg/kg)	see Table C-15	
Cp	Plant concentration (mg/kg)	see Table C-15	
IR	Maximum Ingestion rate of of food (kg/day)*	4.85E-05	EPA, 1993
IR_{max}	Mean Ingestion rate of of food (kg/day)*	4.85E-05	EPA, 1993
Dfe	Dietary fraction of earthworms (unitless)	4.60E-01	EPA, 1993
Dfa	Dietary fraction of arthropods (unitless)	4.60E-01	EPA, 1993
Dfs	Dietary fraction of plants, seeds and other vegetation (unitless)	8.00E-02	EPA, 1993
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	6.30E-02	EPA, 1993
Bw_{mean}	Mean Body weight (kg)	8.40E-02	EPA, 1993

Chemical	Earthworm	Arthropod	Plant	Intake	Refined Intake
4,4-DDD	6.40E-02	6.40E-02	4.76E-04	4.54E-05	3.40E-05
4,4'-DDE	3.54E-03	3.54E-03	2.63E-05	2.51E-06	1.88E-06
4,4'-DDT	1.17E-02	1.17E-02	8.69E-05	8.28E-06	6.21E-06
Aroclor-1254	8.73E-01	8.73E-01	7.73E-03	6.19E-04	4.64E-04
Barium	7.27E+01	7.27E+01	4.96E+01	5.45E-02	4.09E-02
Chromium	1.78E-01	1.78E-01	1.33E-01	1.34E-04	1.00E-04
Copper	1.60E+00	1.60E+00	1.60E+01	2.12E-03	1.59E-03
Zinc	4.57E+02	4.57E+02	9.78E-10	3.23E-01	2.42E-01
TOTAL PAHs	6.03E-01	6.03E-01	1.72E-01	4.38E-04	3.28E-04

TOTAL INTAKE

INTAKE = Soil Intake + Food Intake

Chemical	Total Intake	Refined Intake
4,4-DDD	4.54E-05	3.40E-05
4,4'-DDE	2.81E-06	2.11E-06
4,4'-DDT	8.69E-06	6.52E-06
Aroclor-1254	6.50E-04	4.87E-04
Barium	7.79E-02	5.84E-02
Chromium	1.21E-03	9.06E-04
Copper	4.21E-03	3.16E-03
Zinc	3.66E-01	2.74E-01
TOTAL PAHs	4.24E-01	3.18E-01

Notes:
* Expressed in dry weight.

TABLE C-9
INTAKE CALCULATIONS FOR SOIL SOUTH OF MARLIN
Large Avian Carnivore (RED-TAILED HAWK)

SOIL INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Soil concentration (mg/kg)	see Table C-2	
IR	Maximum Ingestion rate of soil (kg/day)*	8.97E-06	EPA, 1993
IR_{max}	Mean Ingestion rate of soil (kg/day)*	8.97E-06	EPA, 1993
AF	Chemical Bioavailability in soil (unitless)	1	EPA, 1997
AUF	Area Use Factor	1	EPA, 1997
AUF	Area Use Factor - Refined	1.88E-02	EPA, 1997
BW	Minimum Body weight (kg)	9.57E-01	EPA, 1993
Bw_{mean}	Mean Body weight (kg)	1.70E+00	Davis and Schmidly, 2009

Chemical	Sc	Intake	Refined Intake
4,4-DDD	2.70E-04	2.53E-09	2.68E-11
4,4'-DDE	7.52E-03	7.05E-08	7.46E-10
4,4'-DDT	1.03E-02	9.65E-08	1.02E-09
Aroclor-1254	7.64E-01	7.16E-06	7.58E-08
Barium	5.84E+02	5.48E-03	5.80E-05
Chromium	2.68E+01	2.52E-04	2.66E-06
Copper	5.22E+01	4.89E-04	5.18E-06
Zinc	1.06E+03	9.95E-03	1.05E-04
TOTAL PAHs	8.61E+00	8.07E-05	8.54E-07

FOOD INGESTION

INTAKE = ((Cm * IR * Dfm * AUF)/(BW) + (Cb * IR * DFb * AUF) / (BW))

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Cm	Mammal concentration (mg/kg)	see Table C-15	
Cb	Bird concentration (mg/kg)	see Table C-15	
IR	Maximum Ingestion rate of of food (kg/day)*	4.48E-04	EPA, 1993
IR_{max}	Mean Ingestion rate of of food (kg/day)*	4.48E-04	EPA, 1993
Dfm	Dietary fraction of small mammals (unitless)	7.85E-01	EPA, 1993
Dfb	Dietary fraction of birds (unitless)	2.15E-01	EPA, 1993
AUF	Area Use Factor	1	EPA, 1997
AUF	Area Use Factor - Refined	1.88E-02	EPA, 1997
BW	Minimum Body weight (kg)	9.57E-01	EPA, 1993
Bw_{mean}	Mean Body weight (kg)	1.70E+00	Davis and Schmidly, 2009

Chemical	Mammal	Bird	Intake	Refined Intake
4,4-DDD	1.63E-05	3.35E-05	9.34E-09	9.89E-11
4,4'-DDE	8.99E-07	1.85E-06	5.17E-10	5.47E-12
4,4'-DDT	2.97E-06	6.11E-06	1.71E-09	1.80E-11
Aroclor-1254	2.33E-04	4.61E-04	1.32E-07	1.40E-09
Barium	4.53E-03	4.53E-03	2.12E-06	2.24E-08
Chromium	5.80E-04	5.80E-04	2.71E-07	2.87E-09
Copper	1.81E+01	1.81E+01	8.49E-03	8.99E-05
Zinc	1.05E-04	1.02E-01	1.03E-05	1.09E-07
TOTAL PAHs	1.02E-02	1.40E-02	5.17E-06	5.47E-08

TOTAL INTAKE

INTAKE = Soil Intake + Food Intake

Chemical	Total Intake	Refined Intake
4,4-DDD	1.19E-08	1.26E-10
4,4'-DDE	7.10E-08	7.51E-10
4,4'-DDT	9.82E-08	1.04E-09
Aroclor-1254	7.29E-06	7.72E-08
Barium	5.48E-03	5.80E-05
Chromium	2.52E-04	2.67E-06
Copper	8.98E-03	9.50E-05
Zinc	9.96E-03	1.05E-04
TOTAL PAHs	8.59E-05	9.09E-07

Notes:
* Expressed in dry weight.

TABLE C-10
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL SOUTH OF MARLIN
Small Mammalian Herbivore (DEER MOUSE)

Ecological Hazard Quotient = Intake/TRV

Parameter	Definition	Default
Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table C-3

Chemical	Intake	Refined Intake	TRV (deer mouse)	EHQ	Refined EHQ
4,4-DDD	3.41E-05	2.50E-05	1.47E-01	2.32E-04	1.70E-04
4,4'-DDE	1.89E-06	1.38E-06	1.47E-01	1.28E-05	9.41E-06
4,4'-DDT	6.22E-06	4.56E-06	1.47E-01	4.23E-05	3.10E-05
Aroclor-1254	4.71E-04	3.50E-04	1.55E-01	3.04E-03	2.26E-03
Barium	2.59E-01	1.86E-01	5.18E+01	5.00E-03	3.60E-03
Chromium	6.87E-04	1.57E-03	2.40E+00	2.86E-04	6.55E-04
Copper	7.28E-02	4.91E-02	5.60E+00	1.30E-02	8.76E-03
Zinc	2.28E-01	1.98E-01	7.54E+01	3.02E-03	2.62E-03
TOTAL PAHs	1.08E-03	1.24E-03			

TABLE C-11
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL SOUTH OF MARLIN
Large Mammalian Carnivore (COYOTE)

Ecological Hazard Quotient = Intake/TRV

Parameter	Definition	Default
Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table C-3

Chemical	Intake	Refined Intake	TRV Coyote	EHQ	Refined EHQ
4,4-DDD	1.79E-07	8.40E-10	1.47E-01	1.22E-06	5.71E-09
4,4'-DDE	9.89E-09	4.65E-11	1.47E-01	6.73E-08	3.16E-10
4,4'-DDT	3.26E-08	1.53E-10	1.47E-01	2.22E-07	1.04E-09
Aroclor-1254	2.72E-06	1.28E-08	1.55E-01	1.75E-05	8.24E-08
Barium	1.14E-03	5.40E-06	4.10E-01	2.78E-03	1.32E-05
Chromium	6.13E-05	2.90E-07	2.40E+00	2.56E-05	1.21E-07
Copper	3.26E-03	1.17E-05	5.60E+00	5.82E-04	2.10E-06
Zinc	2.82E-03	1.33E-05	7.54E+01	3.74E-05	1.77E-07
TOTAL PAHs	3.16E-05	1.47E-07			

TABLE C-12
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL SOUTH OF MARLIN
Small Mammalian Omnivore (LEAST SHREW)

Ecological Hazard Quotient = Intake/TRV

Parameter	Definition	Default
Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table C-3

Chemical	Intake	Refined Intake	TRV Least Shrew	EHQ	Refined EHQ
4,4-DDD	5.22E-05	3.63E-05	1.47E-01	3.55E-04	2.47E-04
4,4'-DDE	2.89E-06	2.01E-06	1.47E-01	1.96E-05	1.37E-05
4,4'-DDT	9.52E-06	6.62E-06	1.47E-01	6.47E-05	4.50E-05
Aroclor-1254	7.17E-04	4.99E-04	1.55E-01	4.63E-03	3.22E-03
Barium	8.19E-02	5.69E-02	5.18E+01	1.58E-03	1.10E-03
Chromium	1.35E-03	9.38E-04	2.40E+00	5.62E-04	3.91E-04
Copper	5.29E-03	3.68E-03	5.60E+00	9.45E-04	6.57E-04
Zinc	4.02E-01	2.80E-01	7.54E+01	5.34E-03	3.71E-03
TOTAL PAHs	1.06E-03	7.35E-04			

TABLE C-13
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL SOUTH OF MARLIN
Avian Herbivore/Omnivore (AMERICAN ROBIN)

Ecological Hazard Quotient = Intake/TRV

Parameter	Definition	Default
Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table C-3

Chemical	Intake	Refined Intake	TRV American Robin	EHQ	Refined EHQ
4,4-DDD	4.54E-05	3.40E-05	2.27E-01	2.00E-04	1.50E-04
4,4'-DDE	2.81E-06	2.11E-06	2.27E-01	1.24E-05	9.28E-06
4,4'-DDT	8.69E-06	6.52E-06	2.27E-01	3.83E-05	2.87E-05
Aroclor-1254	6.50E-04	4.87E-04	1.80E-01	3.61E-03	2.71E-03
Barium	7.79E-02	5.84E-02	1.91E+01	4.08E-03	3.06E-03
Chromium	1.21E-03	9.06E-04	2.66E+00	4.54E-04	3.40E-04
Copper	4.21E-03	3.16E-03	4.05E+00	1.04E-03	7.80E-04
Zinc	3.66E-01	2.74E-01	6.61E+01	5.53E-03	4.15E-03
TOTAL PAHs	4.24E-01	3.18E-01	0.00E+00		

TABLE C-14
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL SOUTH OF MARLIN
Large Avian Carnivore (RED-TAILED HAWK)

Ecological Hazard Quotient = Intake/TRV

Parameter	Definition	Default
Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table C-3

Chemical	Intake	Refined Intake	TRV Red-Tailed Hawk	EHQ	Refined EHQ
4,4-DDD	1.19E-08	1.26E-10	2.27E-01	5.23E-08	5.54E-10
4,4'-DDE	7.10E-08	7.51E-10	2.27E-01	3.13E-07	3.31E-09
4,4'-DDT	9.82E-08	1.04E-09	2.27E-01	4.33E-07	4.58E-09
Aroclor-1254	7.29E-06	7.72E-08	1.80E-01	4.05E-05	4.29E-07
Barium	5.48E-03	5.80E-05	3.15E+01	1.74E-04	1.84E-06
Chromium	2.52E-04	2.67E-06	2.66E+00	9.47E-05	1.00E-06
Copper	8.98E-03	9.50E-05	4.05E+00	2.22E-03	2.35E-05
Zinc	9.96E-03	1.05E-04	6.61E+01	1.51E-04	1.60E-06
TOTAL PAHs	8.59E-05	9.09E-07			

TABLE C-15
CONCENTRATION OF CHEMICAL IN FOOD ITEM (mg/kg)

Cfood = Csoil x BCF (or BAF)

where:

Cfood =	Chemical Concentration in food (mg/kg dry)
Csoil =	Chemical Concentration in soil (mg/kg dry)
BCF	Bioconcentration Factor (unitless)
BAF =	Bioaccumulation Factor (unitless)

Compound	Csoil (mg/kg)	Soil to Earthworm BCF	Earthworm Concentration	Reference	Soil to Arthropod BCF	Arthropod Concentration	Reference	Soil to Plant BAF	Plant/Fruit/Seed Concentration	Reference
4,4-DDD	5.08E-02	1.26E+00	6.40E-02	EPA, 1999	1.26E+00	6.40E-02	EPA, 1999	9.37E-03	4.76E-04	EPA, 1999
4,4'-DDE	2.81E-03	1.26E+00	3.54E-03	EPA, 1999	1.26E+00	3.54E-03	EPA, 1999	9.37E-03	2.63E-05	EPA, 1999
4,4'-DDT	9.27E-03	1.26E+00	1.17E-02	EPA, 1999	1.26E+00	1.17E-02	EPA, 1999	9.37E-03	8.69E-05	EPA, 1999
Aroclor-1254	7.73E-01	1.13E+00	8.73E-01	EPA, 1999	1.13E+00	8.73E-01	EPA, 1999	1.00E-02	7.73E-03	EPA, 1999
Barium	3.30E+02	2.20E-01	7.27E+01	Sample, 199	2.20E-01	7.27E+01	Sample, 199	1.50E-01	4.96E+01	Bechtel, 199
Chromium	1.78E+01	1.00E-02	1.78E-01	Sample, 199	1.00E-02	1.78E-01	Sample, 199	7.50E-03	1.33E-01	Bechtel, 199
Copper	4.01E+01	4.00E-02	1.60E+00	EPA, 1999	4.00E-02	1.60E+00	EPA, 1999	4.00E-01	1.60E+01	EPA, 1999
Zinc	8.15E+02	5.60E-01	4.57E+02	EPA, 1999	5.60E-01	4.57E+02	EPA, 1999	1.20E-12	9.78E-10	EPA, 1999
TOTAL PAHs	8.61E+00	7.00E-02	6.03E-01	EPA, 1999*	7.00E-02	6.03E-01	EPA, 1999*	2.00E-02	1.72E-01	EPA, 1999*

Compound	Plant to Wildlife BCF	Plant to Deer Mouse Concentration	Reference	Soil to Wildlife BCF	Soil to Deer Mouse Concentration	Reference	TOTAL DEER MOUSE CONCENTRATION
4,4-DDD	2.72E-02	1.29E-05	EPA, 1999	6.52E-05	3.31E-06	EPA, 1999	1.63E-05
4,4'-DDE	2.72E-02	7.16E-07	EPA, 1999	6.52E-05	1.83E-07	EPA, 1999	8.99E-07
4,4'-DDT	2.72E-02	2.36E-06	EPA, 1999	6.52E-05	6.04E-07	EPA, 1999	2.97E-06
Aroclor-1254	2.43E-02	1.88E-04	EPA, 1999	5.83E-05	4.51E-05	EPA, 1999	2.33E-04
Barium	8.99E-05	4.46E-03	EPA, 1999	2.16E-07	7.14E-05	Sample, 1998a	4.53E-03
Chromium	3.30E-03	4.39E-04	EPA, 1999	7.91E-06	1.40E-04	Sample, 1998a	5.80E-04
Copper	1.00E+00	1.60E+01	**	5.25E-02	2.10E+00	Sample, 1998a	1.81E+01
Zinc	5.39E-05	5.27E-14	EPA, 1999	1.29E-07	1.05E-04	EPA, 1999	1.05E-04
TOTAL PAHs	5.31E-02	9.15E-03	EPA, 1999*	1.27E-04	1.09E-03	EPA, 1999*	1.02E-02

Compound	Plant to Bird BCF	Plant to Bird Concentration	Reference	Soil to Bird BCF	Soil to Bird Concentration	Reference	TOTAL BIRD CONCENTRATION
4,4-DDD	1.59E-02	7.57E-06	EPA, 1999	5.10E-04	2.59E-05	EPA, 1999	3.35E-05
4,4'-DDE	1.59E-02	4.19E-07	EPA, 1999	5.10E-04	1.43E-06	EPA, 1999	1.85E-06
4,4'-DDT	1.59E-02	1.38E-06	EPA, 1999	5.10E-04	4.73E-06	EPA, 1999	6.11E-06
Aroclor-1254	1.42E-02	1.10E-04	EPA, 1999	4.55E-04	3.52E-04	EPA, 1999	4.61E-04
Barium	8.99E-05	4.46E-03	EPA, 1999	2.16E-07	7.14E-05	Sample, 199	4.53E-03
Chromium	3.30E-03	4.39E-04	EPA, 1999	7.91E-06	1.40E-04	Sample, 199	5.80E-04
Copper	1.00E+00	1.60E+01	**	5.25E-02	2.10E+00	Sample, 199	1.81E+01
Zinc	3.89E-03	3.81E-12	EPA, 1999	1.25E-04	1.02E-01	EPA, 1999	1.02E-01
TOTAL PAHs	3.11E-02	5.36E-03	EPA, 1999*	9.98E-04	8.60E-03	EPA, 1999*	1.40E-02

Notes:
For vanadium and molybdenum, the BCF values for chromium were used since they are in transitional elements with similar properties.
* For BAFs and BCFs for LPAHs and HPAHs, the most conservative value for the individual PAHs was used to estimated food concentrations.
**If no BAF or BCF was available in the literature, a default value of 1.0 was used.

APPENDIX D

ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR NORTH AREA SOIL

TABLE D-1
EXPOSURE POINT CONCENTATION (mg/kg)
SOIL NORTH OF MARLIN AVE.*

Parameter	Exposure Point Concentration	Statistic Used
4,4'-DDT	8.18E-02	97.5% KM (Chebyshev)
Aroclor-1254	< 4.30E-03	median
Barium	2.08E+02	95% Chebyshev
Chromium	2.27E+01	95% Student's-t
Copper	4.48E+01	95% Chebyshev
Zinc	1.18E+03	97.5% Chebyshev

Notes:
NC - Not a COPEC because it was not measured in greater than five percent of all North Area soils.
* Soil data includes soil collected from 0 to 2 feet below ground surface.

TABLE D-2
EXPOSURE POINT CONCENTATION (mg/kg)
SURFACE SOIL NORTH OF MARLIN AVE.*

Parameter	Exposure Point Concentration	Statistic Used
4,4'-DDT	< 5.00E-04	median
Aroclor-1254	< 4.29E-03	median
Barium	2.64E+02	95% Chebyshev
Chromium	4.86E+01	95% Chebyshev
Copper	7.00E+01	95% Chebyshev
Zinc	2.34E+03	97.5% Chebyshev

Notes:
* Surface soil data includes soil collected from 0 to 0.5 feet below ground surface.
NS - Not sampled in surface soil.

TABLE D-3
TOXICITY REFERENCE VALUES

Parameter	Invertebrate (Earthworm) (mg/kg)	Ref.	Comments	Small Mammalian Herbivore (Deer Mouse) (mg/kgBW-day)	Ref.	Comments	Large Mammalian Carnivore (Coyote) (mg/kgBW-day)	Ref.	Comments	Small Mammalian Omnivore (Least Shrew) (mg/kgBW-day)	Ref.	Comments	Avian Herbivore/Omnivore (American Robin) (mg/kgBW-day)	Ref.	Comments	Large Avian Carnivore (Red-tailed Hawk) (mg/kgBW-day)	Ref.	Comments
4,4'-DDT	4.30E-02	EPA, 2007a	Acute median LC50 in common cricket (dose 4.3 with uncertainty factor of 0.01)	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	1.47E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
Aroclor-1254	2.51E+00	EPA, 1999	Acute median LC50 in earthworms (dose 251 with uncertainty factor of 0.01)	1.55E-01	Sample, 1996	Chronic LOAEL for reproduction in mouse with an uncertainty factor of 0.1	1.55E-01	Sample, 1996	Chronic LOAEL for reproduction in mouse with an uncertainty factor of 0.1	1.55E-01	Sample, 1996	Chronic LOAEL for reproduction in mouse with an uncertainty factor of 0.1	1.80E-01	Sample, 1996		1.80E-01	Sample, 1996	
Barium	3.30E+02	EPA, 2005g	Geometric mean of the EC20 values for three test species under three separate test conditions of pH	5.18E+01	EPA, 2005g	Geometric mean of NOAEL values for reproduction and growth	5.18E+01	EPA, 2005g	Geometric mean of NOAEL values for reproduction and growth	5.18E+01	EPA, 2005g	Geometric mean of NOAEL values for reproduction and growth	1.91E+01	EPA, 1999		3.15E+01	EPA, 1999	
Chromium	5.70E+01	EPA, 2005c	Maximum acceptable toxicant concentration (MATC) for reproductive effects in earthworm	2.40E+00	EPA, 2005c	Geometric mean of NOAEL values for reproduction and growth	2.40E+00	EPA, 2005c	Geometric mean of NOAEL values for reproduction and growth	2.40E+00	EPA, 2005c	Geometric mean of NOAEL values for reproduction and growth	2.66E+00	EPA, 2005c	Geometric mean of the NOAEL values for reproduction and growth	2.66E+00	EPA, 2005c	Geometric mean of the NOAEL values for reproduction and growth
Copper	8.00E+01	EPA, 2007c	Geometric mean of the MATC and EC10 values for six test species under different test species	5.60E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	5.60E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	5.60E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	4.05E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	4.05E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
Zinc	1.20E+02	EPA, 2007e	Geometric mean of the MATC and EC10 values for three test species under different test species	7.54E+01	EPA, 2007e	Geometric mean of NOAEL values for reproduction and growth	7.54E+01	EPA, 2007e	Geometric mean of NOAEL values for reproduction and growth	7.54E+01	EPA, 2007e	Geometric mean of NOAEL values for reproduction and growth	6.61E+01	EPA, 2007e	Geometric mean of NOAEL values within the reproductive and growth effect groups	6.61E+01	EPA, 2007e	Geometric mean of NOAEL values within the reproductive and growth effect groups

Notes:
EPA, 2007a – DDT
EPA, 2007c – Copper
EPA, 2007e – Zinc
EPA, 2005c – Chromium
EPA, 2005g – Barium

TABLE D-4
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL NORTH OF MARLIN
Invertebrate (EARTHWORM)

Ecological Hazard Quotient = Sc/TRV

Parameter	Definition	Default
Sc	Soil Concentration (mg/kg)	see below
TRV	Toxicity Reference Value (mg/kg)	see Table D-3

Chemical	Exposure Point Concentration* (Sc)	TRV (earthworm)	Maximum EHQ⁺
4,4'-DDT	3.95E-01	4.30E-02	9.19E+00
Aroclor-1254	6.35E+00	2.51E+00	2.53E+00
Barium	4.76E+02	3.30E+02	1.44E+00
Chromium	1.28E+02	5.70E+01	2.25E+00
Copper	2.00E+02	8.00E+01	2.50E+00
Zinc	5.64E+03	1.20E+02	4.70E+01

Notes:
*EPC for sedentary receptor is maximum measured concentration.
⁺Shading indicates HQ>1

TABLE D-5
INTAKE CALCULATIONS FOR SOIL NORTH OF MARLIN
Small Mammalian Herbivore (DEER MOUSE)

SOIL INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Soil concentration (mg/kg)	See Table D-1	
IR	Maximum Ingestion rate of soil (kg/day)*	1.50E-06	EPA, 1993
IR_{max}	Mean Ingestion rate of soil (kg/day)*	1.50E-06	EPA, 1993
AF	Chemical Bioavailability in soil (unitless)	1	EPA, 1997
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	1.50E+02	Davis and Schmidly, 2009
Bw_{mean}	Mean Body weight (kg)	2.35E-02	Davis and Schmidly, 2009

Chemical	Sc	Intake	Refined Intake
4,4'-DDT	8.18E-02	8.18E-10	5.22E-06
Aroclor-1254	4.30E-03	4.30E-11	2.74E-07
Barium	2.08E+02	2.08E-06	1.33E-02
Chromium	2.27E+01	2.27E-07	1.45E-03
Copper	4.48E+01	4.48E-07	2.86E-03
Zinc	1.18E+03	1.18E-05	7.54E-02

FOOD INGESTION

INTAKE = ((Ca * IR * DFa * AUF) / (BW) + ((Cp * IR * DFs *AUF)/(BW))

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Ca	Arthropod concentration (mg/kg)	see Table D-15	
Cp	Plant concentration (mg/kg)	see Table D-15	
IR	Maximum Ingestion rate of of food (kg/day)*	7.49E-05	EPA, 1993
IR_{max}	Mean Ingestion rate of of food (kg/day)*	7.49E-05	EPA, 1993
Dfa	Dietary fraction of arthropods (unitless)	1.00E-01	Prof Judgment
Dfs	Dietary fraction of plants, seeds and other vegetation (unitless)	9.00E-01	Prof Judgment
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	1.50E-02	Davis and Schmidly, 2009
Bw_{mean}	Mean Body weight (kg)	2.35E-02	Davis and Schmidly, 2009

Chemical	Arthropod	Plant	Intake	Refined Intake
4,4'-DDT	1.03E-01	7.66E-04	5.49E-05	3.50E-05
Aroclor-1254	4.86E-03	4.30E-05	2.62E-06	1.67E-06
Barium	4.58E+01	3.13E+01	1.63E-01	1.04E-01
Chromium	2.27E-01	1.70E-01	8.78E-04	5.61E-04
Copper	1.79E+00	1.79E+01	8.15E-02	5.20E-02
Zinc	6.61E+02	1.42E-09	3.30E-01	2.11E-01

TOTAL INTAKE

INTAKE = Soil Intake + Food Intake

Chemical	Total Intake	Refined Intake
4,4'-DDT	5.49E-05	4.03E-05
Aroclor-1254	2.62E-06	1.95E-06
Barium	1.63E-01	1.18E-01
Chromium	8.79E-04	2.01E-03
Copper	8.15E-02	5.49E-02
Zinc	3.30E-01	2.86E-01

Notes:
* Expressed in dry weight.

TABLE D-6
INTAKE CALCULATIONS FOR SOIL NORTH OF MARLIN
Large Mammalian Carnivore (COYOTE)

SOIL INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Soil concentration (mg/kg)	see Table D-1	
IR	Maximum Ingestion rate of soil (kg/day)*	4.83E-05	EPA, 1993
IR_{max}	Mean Ingestion rate of soil (kg/day)*	4.83E-05	EPA, 1993
AF	Chemical Bioavailability in soil (unitless)	1	EPA, 1997
AUF	Area Use Factor	1	EPA, 1997
AUF	Area Use Factor - Refined	5.75E-03	Sample et al., 1997
BW	Minimum Body weight (kg)	1.40E+01	Davis and Schmidly, 2009
Bw_{mean}	Mean Body weight (kg)	1.70E+01	Davis and Schmidly, 2009

Chemical	Sc	Intake	Refined Intake
4,4'-DDT	8.18E-02	2.82E-07	1.34E-09
Aroclor-1254	4.30E-03	1.48E-08	7.02E-11
Barium	2.08E+02	7.19E-04	3.40E-06
Chromium	2.27E+01	7.83E-05	3.71E-07
Copper	4.48E+01	1.55E-04	7.32E-07
Zinc	1.18E+03	4.07E-03	1.93E-05

FOOD INGESTION

INTAKE = ((Cm * IR * Dfm * AUF)/(BW) + (Cb * IR * DFb * AUF) / (BW))

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Cm	Mammal concentration (mg/kg)	see Table D-15	
Cb	Bird concentration (mg/kg)	see Table D-15	
IR	Maximum Ingestion rate of of food (kg/day)*	2.41E-03	EPA, 1993
IR_{max}	Mean Ingestion rate of of food (kg/day)*	2.41E-03	EPA, 1993
Dfm	Dietary fraction of small mammals (unitless)	7.50E-01	EPA, 1993
Dfb	Dietary fraction of birds (unitless)	2.50E-01	EPA, 1993
AUF	Area Use Factor	1	EPA, 1997
AUF	Area Use Factor - Refined	5.75E-03	Sample et al., 1997
BW	Minimum Body weight (kg)	1.40E+01	EPA, 1993
Bw_{mean}	Mean Body weight (kg)	1.70E+01	Davis and Schmidly, 2009

Chemical	Mammal	Bird	Intake	Refined Intake
4,4'-DDT	2.62E-05	5.39E-05	5.70E-09	2.70E-11
Aroclor-1254	1.30E-06	2.57E-06	2.78E-10	1.32E-12
Barium	2.86E-03	2.86E-03	4.92E-07	2.33E-09
Chromium	7.41E-04	7.41E-04	1.28E-07	6.04E-10
Copper	2.03E+01	2.03E+01	3.49E-03	1.65E-05
Zinc	1.52E-04	1.48E-01	6.37E-06	3.02E-08

TOTAL INTAKE

INTAKE = Soil Intake + Food Intake

Chemical	Total Intake	Refined Intake
4,4'-DDT	2.88E-07	1.36E-09
Aroclor-1254	1.51E-08	7.16E-11
Barium	7.19E-04	3.41E-06
Chromium	7.84E-05	3.71E-07
Copper	3.65E-03	1.73E-05
Zinc	4.08E-03	1.93E-05

Notes:
* Expressed in dry weight.

TABLE D-7
INTAKE CALCULATIONS FOR SOIL NORTH OF MARLIN
Small Mammalian Omnivore (LEAST SHREW)

SOIL INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	*Soil concentration (mg/kg)*	see Table D-1	
IR	Maximum Ingestion rate of soil (kg/day)*	2.71E-07	EPA, 1993
IR_{max}	Mean Ingestion rate of soil (kg/day)*	2.71E-07	EPA, 1993
AF	Chemical Bioavailability in soil (unitless)	1	EPA, 1997
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	4.00E-03	Davis and Schmidly, 2009
BW_{mean}	Mean Body weight (kg)	5.75E-03	Davis and Schmidly, 2009

Chemical	Sc	Intake	Refined Intake
4,4'-DDT	8.18E-02	5.54E-06	3.86E-06
Aroclor-1254	4.30E-03	2.91E-07	2.03E-07
Barium	2.08E+02	1.41E-02	9.82E-03
Chromium	2.27E+01	1.54E-03	1.07E-03
Copper	4.48E+01	3.04E-03	2.11E-03
Zinc	1.18E+03	8.00E-02	5.57E-02

FOOD INGESTION

INTAKE = ((Ca * IR * DFa * AUF) / (BW) + ((Cp * IR * DFs *AUF)/(BW))

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Ca	Arthropod concentration (mg/kg)	*see Table D-15*	
Cp	Plant concentration (mg/kg)	see Table D-15	
IR	Maximum Ingestion rate of of food (kg/day)*	3.38E-06	EPA, 1993
IR_{max}	Mean Ingestion rate of of food (kg/day)*	3.38E-06	EPA, 1993
Dfa	Dietary fraction of arthropods (unitless)	9.00E-01	EPA, 1993
Dfs	Dietary fraction of plants, seeds and other vegetation (unitless)	1.00E-01	EPA, 1993
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	4.00E-03	Davis and Schmidly, 2009
BW_{mean}	Mean Body weight (kg)	5.75E-03	Davis and Schmidly, 2009

Chemical	Arthropod	Plant	Intake	Refined Intake
4,4'-DDT	1.03E-01	7.66E-04	7.84E-05	5.46E-05
Aroclor-1254	4.86E-03	4.30E-05	3.70E-06	2.57E-06
Barium	4.58E+01	3.13E+01	3.75E-02	2.61E-02
Chromium	2.27E-01	1.70E-01	1.87E-04	1.30E-04
Copper	1.79E+00	1.79E+01	2.88E-03	2.00E-03
Zinc	6.61E+02	1.42E-09	5.03E-01	3.50E-01

TOTAL INTAKE

INTAKE = Soil Intake + Food Intake

Chemical	Total Intake	Refined Intake
4,4'-DDT	8.40E-05	5.84E-05
Aroclor-1254	3.99E-06	2.78E-06
Barium	5.16E-02	3.59E-02
Chromium	1.72E-03	1.20E-03
Copper	5.91E-03	4.11E-03
Zinc	5.83E-01	4.06E-01

Notes:
* Expressed in dry weight.
* Soil ingestion was assumed to be 8% of dietary intake.

TABLE D-8
INTAKE CALCULATIONS FOR SOIL NORTH OF MARLIN
Avian Herbivore/Omnivore (AMERICAN ROBIN)

SOIL INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Soil concentration (mg/kg)	see Table D-2	
IR	Maximum Ingestion rate of soil (kg/day)*	2.52E-06	EPA, 1993
IR_{max}	Mean Ingestion rate of soil (kg/day)*	2.52E-06	EPA, 1993
AF	Chemical Bioavailability in soil (unitless)	1	EPA, 1997
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	6.30E-02	EPA, 1993
Bw_{mean}	Mean Body weight (kg)	8.40E-02	EPA, 1993

Chemical	Sc	Intake	Refined Intake
4,4'-DDT	5.00E-04	2.00E-08	1.50E-08
Aroclor-1254	4.29E-03	1.72E-07	1.29E-07
Barium	2.64E+02	1.06E-02	7.93E-03
Chromium	4.86E+01	1.94E-03	1.46E-03
Copper	7.00E+01	2.80E-03	2.10E-03
Zinc	2.34E+03	9.37E-02	7.03E-02

FOOD INGESTION

INTAKE = ((Ce * IR * Dfe * AUF)/(BW) + (Ca * IR * DFa * AUF) / (BW) + ((Cp * IR * DFs *AUF)/(BW))

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Ce	Earthworm concentration (mg/kg)	see Table D-15	
Ca	Arthropod concentration (mg/kg)	see Table D-15	
Cp	Plant concentration (mg/kg)	see Table D-15	
IR	Maximum Ingestion rate of of food (kg/day)*	4.85E-05	EPA, 1993
IR_{max}	Mean Ingestion rate of of food (kg/day)*	4.85E-05	EPA, 1993
Dfe	Dietary fraction of earthworms (unitless)	4.60E-01	EPA, 1993
Dfa	Dietary fraction of arthropods (unitless)	4.60E-01	EPA, 1993
Dfs	Dietary fraction of plants, seeds and other vegetation (unitless)	8.00E-02	EPA, 1993
AUF	Area Use Factor	1	EPA, 1997
BW	Minimum Body weight (kg)	6.30E-02	EPA, 1993
Bw_{mean}	Mean Body weight (kg)	8.40E-02	EPA, 1993

Chemical	Earthworm	Arthropod	Plant	Intake	Refined Intake
4,4'-DDT	1.03E-01	1.03E-01	7.66E-04	7.30E-05	5.48E-05
Aroclor-1254	4.86E-03	4.86E-03	4.30E-05	3.44E-06	2.58E-06
Barium	4.58E+01	4.58E+01	3.13E+01	3.44E-02	2.58E-02
Chromium	2.27E-01	2.27E-01	1.70E-01	1.71E-04	1.28E-04
Copper	1.79E+00	1.79E+00	1.79E+01	2.37E-03	1.78E-03
Zinc	6.61E+02	6.61E+02	1.42E-09	4.68E-01	3.51E-01

TOTAL INTAKE

INTAKE = Soil Intake + Food Intake

Chemical	Total Intake	Refined Total Intake
4,4'-DDT	7.31E-05	5.48E-05
Aroclor-1254	3.62E-06	2.71E-06
Barium	4.50E-02	3.37E-02
Chromium	2.11E-03	1.59E-03
Copper	5.17E-03	3.88E-03
Zinc	5.62E-01	4.22E-01

Notes:
* Expressed in dry weight.

TABLE D-9
INTAKE CALCULATIONS FOR SOIL NORTH OF MARLIN
Large Avian Carnivore (RED-TAILED HAWK)

SOIL INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Soil concentration (mg/kg)	see Table D-2	
IR	Maximum Ingestion rate of soil (kg/day)*	8.97E-06	EPA, 1993
IR_{max}	Mean Ingestion rate of soil (kg/day)*	8.97E-06	EPA, 1993
AF	Chemical Bioavailability in soil (unitless)	1	EPA, 1997
AUF	Area Use Factor	1	EPA, 1997
AUF	Area Use Factor - Refined	1.88E-02	EPA, 1997
BW	Minimum Body weight (kg)	9.57E-01	EPA, 1993
Bw_{mean}	Mean Body weight (kg)	1.70E+00	avis and Schmidly, 2009

Chemical	Sc	Intake	Refined Intake
4,4'-DDT	5.00E-04	4.69E-09	4.96E-11
Aroclor-1254	4.29E-03	4.02E-08	4.26E-10
Barium	2.64E+02	2.48E-03	2.62E-05
Chromium	4.86E+01	4.55E-04	4.82E-06
Copper	7.00E+01	6.56E-04	6.94E-06
Zinc	2.34E+03	2.20E-02	2.32E-04

FOOD INGESTION

INTAKE = ((Cm * IR * Dfm * AUF)/(BW) + (Cb * IR * DFb * AUF) / (BW))

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Cm	Mammal concentration (mg/kg)	see Table D-15	
Cb	Bird concentration (mg/kg)	see Table D-15	
IR	Maximum Ingestion rate of of food (kg/day)*	4.48E-04	EPA, 1993
IR_{max}	Mean Ingestion rate of of food (kg/day)*	4.48E-04	EPA, 1993
Dfm	Dietary fraction of small mammals (unitless)	7.85E-01	EPA, 1993
Dfb	Dietary fraction of birds (unitless)	1.00E+00	EPA, 1993
AUF	Area Use Factor	1	EPA, 1997
AUF	Area Use Factor - Refined	1.88E-02	EPA, 1997
BW	Minimum Body weight (kg)	9.57E-01	EPA, 1993
Bw_{mean}	Mean Body weight (kg)	1.70E+00	Davis and Schmidly, 2009

Chemical	Mammal	Bird	Intake	Refined Intake
4,4'-DDT	2.62E-05	5.39E-05	3.49E-08	3.69E-10
Aroclor-1254	1.30E-06	2.57E-06	1.68E-09	1.78E-11
Barium	2.86E-03	2.86E-03	2.39E-06	2.53E-08
Chromium	7.41E-04	7.41E-04	6.20E-07	6.56E-09
Copper	2.03E+01	2.03E+01	1.69E-02	1.79E-04
Zinc	1.52E-04	1.48E-01	6.92E-05	7.32E-07

TOTAL INTAKE

INTAKE = Soil Intake + Food Intake

Chemical	Total Intake	Total Refined Intake
4,4'-DDT	3.95E-08	4.18E-10
Aroclor-1254	4.19E-08	4.43E-10
Barium	2.48E-03	2.62E-05
Chromium	4.56E-04	4.83E-06
Copper	1.76E-02	1.86E-04
Zinc	2.20E-02	2.33E-04

Notes:
* Expressed in dry weight.

TABLE D-10
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL NORTH OF MARLIN
Small Mammalian Herbivore (DEER MOUSE)

Ecological Hazard Quotient = Intake/TRV

Parameter	*Definition*	*Default*
Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table D-3

Chemical	Intake	Refined Intake	TRV (deer mouse)		EHQ	Refined EHQ
4,4'-DDT	5.49E-05	4.03E-05	1.47E-01		3.74E-04	2.74E-04
Aroclor-1254	2.62E-06	1.95E-06	1.55E-01	<	1.69E-05	1.26E-05
Barium	1.63E-01	1.18E-01	5.18E+01		3.15E-03	2.27E-03
Chromium	8.79E-04	2.01E-03	2.40E+00		3.66E-04	8.37E-04
Copper	8.15E-02	5.49E-02	5.60E+00		1.45E-02	9.80E-03
Zinc	3.30E-01	2.86E-01	7.54E+01		4.38E-03	3.80E-03

TABLE D-11
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL NORTH OF MARLIN
Large Mammalian Carnivore (COYOTE)

Ecological Hazard Quotient = Intake/TRV

Parameter	Definition	Default
Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table D-3

Chemical	Intake	Refined Intake	TRV Coyote		EHQ	Refined EHQ
4,4'-DDT	2.88E-07	1.36E-09	1.47E-01		1.96E-06	9.27E-09
Aroclor-1254	1.51E-08	7.16E-11	1.55E-01	<	9.75E-08	4.62E-10
Barium	7.19E-04	3.41E-06	5.18E+01		1.39E-05	6.58E-08
Chromium	7.84E-05	3.71E-07	2.40E+00		3.27E-05	1.55E-07
Copper	3.65E-03	1.73E-05	5.60E+00		6.51E-04	3.08E-06
Zinc	4.08E-03	1.93E-05	7.54E+01		5.41E-05	2.56E-07

TABLE D-12
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL NORTH OF MARLIN
Small Mammalian Omnivore (LEAST SHREW)

Ecological Hazard Quotient = Intake/TRV

Parameter	Definition	Default
Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table D-3

Chemical	Intake	Refined Intake	TRV Least Shrew		EHQ	Refined EHQ
4,4'-DDT	8.40E-05	5.84E-05	1.47E-01		5.71E-04	3.97E-04
Aroclor-1254	3.99E-06	2.78E-06	1.55E-01	<	2.57E-05	1.79E-05
Barium	5.16E-02	3.59E-02	5.18E+01		9.97E-04	6.93E-04
Chromium	1.72E-03	1.20E-03	2.40E+00		7.19E-04	5.00E-04
Copper	5.91E-03	4.11E-03	5.60E+00		1.06E-03	7.35E-04
Zinc	5.83E-01	4.06E-01	7.54E+01		7.73E-03	5.38E-03

TABLE D-13
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL NORTH OF MARLIN
Avian Herbivore/Omnivore (AMERICAN ROBIN)

Ecological Hazard Quotient = Intake/TRV

Parameter	Definition	Default
Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table D-3

Chemical	Intake	Refined Intake	TRV American Robin		EHQ	Refined EHQ
4,4'-DDT	7.31E-05	5.48E-05	2.27E-01	<	3.22E-04	2.41E-04
Aroclor-1254	3.62E-06	2.71E-06	1.80E-01	<	2.01E-05	1.51E-05
Barium	4.50E-02	3.37E-02	1.91E+01		2.35E-03	1.77E-03
Chromium	2.11E-03	1.59E-03	2.66E+00		7.95E-04	5.96E-04
Copper	5.17E-03	3.88E-03	4.05E+00		1.28E-03	9.58E-04
Zinc	5.62E-01	4.22E-01	6.61E+01		8.50E-03	6.38E-03

TABLE D-14
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SOIL NORTH OF MARLIN
Large Avian Carnivore (RED-TAILED HAWK)

Ecological Hazard Quotient = Intake/TRV

Parameter	Definition	Default
Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table D-3

Chemical	Intake	Refined Intake	TRV Red-Tailed Hawk		EHQ	Refined EHQ
4,4'-DDT	3.95E-08	4.18E-10	2.27E-01	<	1.74E-07	1.84E-09
Aroclor-1254	4.19E-08	4.43E-10	1.80E-01	<	2.33E-07	2.46E-09
Barium	2.48E-03	2.62E-05	3.15E+01		7.87E-05	8.33E-07
Chromium	4.56E-04	4.83E-06	2.66E+00		1.71E-04	1.81E-06
Copper	1.76E-02	1.86E-04	4.05E+00		4.35E-03	4.60E-05
Zinc	2.20E-02	2.33E-04	6.61E+01		3.33E-04	3.53E-06

TABLE D-15
CONCENTRATION OF CHEMICAL IN FOOD ITEM (mg/kg)

Cfood = Csoil x BCF (or BAF)

where:

Cfood = Chemical Concentration in food (mg/kg dry)
Csoil = Chemical Concentration in soil (mg/kg dry)
BCF Bioconcentration Factor (unitless)
BAF = Bioaccumulation Factor (unitless)

Compound	Csoil (mg/kg)	Soil to Earthworm BCF	Earthworm Concentration	Reference	Soil to Arthropod BCF	Arthropod Concentration	Reference	Soil to Plant BAF	Plant/Fruit/Seed Concentration	Reference	Plant to Wildlife BCF
4,4'-DDT	8.18E-02	1.26E+00	1.03E-01	EPA, 1999	1.26E+00	1.03E-01	EPA, 1999	9.37E-03	7.66E-04	EPA, 1999	2.72E-02
Aroclor-1254	4.30E-03	1.13E+00	4.86E-03	EPA, 1999	1.13E+00	4.86E-03	EPA, 1999	1.00E-02	4.30E-05	EPA, 1999	2.43E-02
Barium	2.08E+02	2.20E-01	4.58E+01	Sample, 199	2.20E-01	4.58E+01	Sample, 199	1.50E-01	3.13E+01	Bechtel, 1998	8.99E-05
Chromium	2.27E+01	1.00E-02	2.27E-01	Sample, 199	1.00E-02	2.27E-01	Sample, 199	7.50E-03	1.70E-01	Bechtel, 1998	3.30E-03
Copper	4.48E+01	4.00E-02	1.79E+00	EPA, 1999	4.00E-02	1.79E+00	EPA, 1999	4.00E-01	1.79E+01	EPA, 1999	1.00E+00
Zinc	1.18E+03	5.60E-01	6.61E+02	EPA, 1999	5.60E-01	6.61E+02	EPA, 1999	1.20E-12	1.42E-09	EPA, 1999	5.39E-05

Compound	Plant to Deer Mouse Concentration	Reference	Soil to Wildlife BCF	Soil to Deer Mouse Concentration	Reference	TOTAL DEER MOUSE CONCENTRATION	Plant to Bird BCF	Plant to Bird Concentration	Reference	Soil to Bird BCF	Soil to Bird Concentration	Reference	TOTAL BIRD CONCENTRATION
4,4'-DDT	2.08E-05	EPA, 1999	6.52E-05	5.33E-06	EPA, 1999	2.62E-05	1.59E-02	1.22E-05	EPA, 1999	5.10E-04	4.17E-05	EPA, 1999	5.39E-05
Aroclor-1254	1.04E-06	EPA, 1999	5.83E-05	2.51E-07	EPA, 1999	1.30E-06	1.42E-02	6.11E-07	EPA, 1999	4.55E-04	1.96E-06	EPA, 1999	2.57E-06
Barium	2.81E-03	EPA, 1999	2.16E-07	4.50E-05	Sample, 1998a	2.86E-03	8.99E-05	2.81E-03	EPA, 1999	2.16E-07	4.50E-05	Sample, 199	2.86E-03
Chromium	5.62E-04	EPA, 1999	7.91E-06	1.80E-04	Sample, 1998a	7.41E-04	3.30E-03	5.62E-04	EPA, 1999	7.91E-06	1.80E-04	Sample, 199	7.41E-04
Copper	1.79E+01	**	5.25E-02	2.35E+00	Sample, 1998a	2.03E+01	1.00E+00	1.79E+01	**	5.25E-02	2.35E+00	Sample, 199	2.03E+01
Zinc	7.64E-14	EPA, 1999	1.29E-07	1.52E-04	EPA, 1999	1.52E-04	3.89E-03	5.51E-12	EPA, 1999	1.25E-04	1.48E-01	EPA, 1999	1.48E-01

Notes:
+surface soil data were used because it was not a COPEC for all soil.
For vanadium and molybdenum, the BCF values for chromium were used since they are in transitional elements with similar properties.
* For BAFs and BCFs for LPAHs and HPAHs, the most conservative value for the individual PAHs was used to estimated food concentrations.
**If no BAF or BCF was available in the literature, a default value of 1.0 was used.

APPENDIX E

ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR INTRACOASTAL WATERWAY SEDIMENT

TABLE E-1
EXPOSURE POINT CONCENTATION (mg/kg)
INTRACOASTAL WATERWAY SEDIMENT

Parameter		Exposure Point Concentraiton	Statistic Used
SEDIMENT			
4,4'-DDT	<	2.03E-04	median
Acenaphthene	<	1.35E-02	median
Benzo(a)anthracene	<	1.38E-02	99% Chebyshev
Chrysene		2.73E-01	97.5% KM (Chebyshev)
Dibenz(a,h)anthracene	<	1.57E-02	median
Fluoranthene		4.39E-01	97.5% KM (Chebyshev)
Fluorene	<	1.38E-02	median
Hexachlorobenzene	<	1.62E-02	median
Phenanthrene		2.80E-01	97.5% KM (Chebyshev)
Pyrene		4.82E-01	97.5% KM (Chebyshev)
LPAH		3.40E-01	
HPAH		1.88E+00	
TOTAL PAHs		2.22E+00	

TABLE E-2
TOXICITY REFERENCE VALUES

Parameter	Polychaetes (mg/kg)	Ref.	Comments	Polychaetes (mg/kg)	Ref.	Comments	Avian Carnivore (Sandpiper) (mg/kgBW-day)	Ref.	Comments	Avian Carnivore (Green heron) (mg/kgBW-day)	Ref.	Comments
4,4'-DDT	1.19E-03	SQUIRT	ERL	6.29E-02	SQUIRT	ERM	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
Acenaphthene	4.40E-02	SQUIRT	ERL	6.40E-01	SQUIRT	ERM						
Benzo(a)anthracene	2.61E-01	SQUIRT	ERL	1.60E+00	SQUIRT	ERM						
Chrysene	3.84E-01	SQUIRT	ERL	2.80E+00	SQUIRT	ERM						
Dibenz(a,h)anthracene	6.34E-02	SQUIRT	ERL	2.60E-01	SQUIRT	ERM						
Fluoranthene	6.00E-01	SQUIRT	ERL	5.10E+00	SQUIRT	ERM						
Fluorene	1.90E-02	SQUIRT	ERL	5.40E-01	SQUIRT	ERM						
Hexachlorobenzene	6.00E-03	SQUIRT	AET	6.00E-03	SQUIRT	AET	2.25E-01	EPA, 1999	avian TRV for soil	2.25E-01	EPA, 1999	avian TRV for soil
Phenanthrene	2.40E-01	SQUIRT	ERL	1.50E+00	SQUIRT	ERM						
Pyrene	6.65E-01	SQUIRT	ERL	2.60E+00	SQUIRT	ERM						
LPAH	5.52E-01	SQUIRT	ERL	3.16E+00	SQUIRT	ERM						
HPAH	1.70E+00	SQUIRT	ERL	9.60E+00	SQUIRT	ERM						
TOTAL PAHs	4.02E+00	SQUIRT	ERL	4.48E+01	SQUIRT	ERM						

Notes:
ERL – Effects Range-Low
AET – Apparent Effects Threshold
EPA, 2007a – DDT
EPA, 2007b – PAHs

TABLE E-3
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR INTRACOASTAL WATERWAY SEDIMENT
Polychaetes

Ecological Hazard Quotient = Sc/TRV

Parameter	Definition	Default
Sc	Sediment Concentration (mg/kg)	see below
TRV	Toxicity Reference Value (mg/kg)	see Table F-2

Chemical	Exposure Point Concentration* (Sc)	TRV polychaetes	Maximum EHQ+
4,4'-DDT	3.32E-03	1.19E-03	2.79E+00
Acenaphthene	6.31E-02	4.40E-02	1.43E+00
Benzo(a)anthracene	3.95E-01	2.61E-01	1.51E+00
Chrysene	4.75E-01	3.84E-01	1.24E+00
Dibenz(a,h)anthracene	2.35E-01	6.34E-02	3.71E+00
Fluoranthene	8.04E-01	6.00E-01	1.34E+00
Fluorene	4.60E-02	1.90E-02	2.42E+00
Hexachlorobenzene	3.19E-02	6.00E-03	5.32E+00
Phenanthrene	5.08E-01	2.40E-01	2.12E+00
Pyrene	8.62E-01	6.65E-01	1.30E+00
LPAH	7.11E-01	5.52E-01	1.29E+00
HPAH	4.91E+00	1.70E+00	2.89E+00
TOTAL PAHs	5.62E+00	4.02E+00	1.40E+00

Notes:
*EPC for benthic receptors is maximum measured concentration.
+Shading indicates HQ > 1.

TABLE E-4
INTAKE CALCULATIONS FOR INTRACOASTAL WATERWAY SEDIMENT
Avian Carnivore (SANDPIPER)

SEDIMENT INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Sediment concentration (mg/kg)	see Table F-1	
IR - refined	Mean Ingestion rate of sed (kg/day)***	5.34E-06	EPA, 1993
IR	Maximum Ingestion rate of sed (kg/day)***	5.34E-06	EPA, 1993
AF	Chemical Bioavailability in sediment (unitless)	1	EPA, 1997
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	4.25E-02	EPA, 1993
BW	Minimum Body weight (kg)	3.40E-02	EPA, 1993

Chemical	Sc	Intake	Intake - Refined
4,4'-DDT	2.03E-04	3.19E-08	2.55E-08
Acenaphthene	1.35E-02	2.12E-06	1.70E-06
Benzo(a)anthracene	1.38E-02	2.17E-06	1.73E-06
Chrysene	2.73E-01	4.28E-05	3.43E-05
Dibenz(a,h)anthracene	1.57E-02	2.46E-06	1.97E-06
Fluoranthene	4.39E-01	6.89E-05	5.51E-05
Fluorene	1.38E-02	2.17E-06	1.73E-06
Hexachlorobenzene	1.62E-02	2.54E-06	2.03E-06
Phenanthrene	2.80E-01	4.39E-05	3.52E-05
Pyrene	4.82E-01	7.56E-05	6.05E-05
LPAH	3.40E-01	5.33E-05	4.27E-05
HPAH	1.88E+00	2.95E-04	2.36E-04
TOTAL PAHs	2.22E+00	3.48E-04	2.78E-04

FOOD INGESTION

INTAKE = ((Cc * IR * Dfc * AUF)/(BW) + (Cw * IR * DFw * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Cc	Crab concentration (mg/kg)	see Table F-8	
Cw	Worm concentration (mg/kg)	see Table F-8	
IR - refined	Mean Ingestion rate of food (kg/day)***	2.81E-05	EPA, 1993
IR	Maximum Ingestion rate of of food (kg/day)***	2.81E-05	EPA, 1993
Dfc	Dietary fraction of crabs (unitless)	4.00E-01	prof. judgement
Dfw	Dietary fraction of worms (unitless)	6.00E-01	prof. judgement
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	4.25E-02	EPA, 1993
BW	Minimum Body weight (kg)	3.40E-02	EPA, 1993

Chemical	Crab	Worm	Intake	Intake - Refined
4,4'-DDT	2.98E-03	1.62E-04	1.06E-06	8.51E-07
Acenaphthene	1.35E-02	2.17E-02	1.52E-05	1.22E-05
Benzo(a)anthracene	2.92E-01	2.00E-02	1.06E-04	8.51E-05
Chrysene	1.49E-01	3.77E-01	2.36E-04	1.89E-04
Dibenz(a,h)anthracene	2.47E-01	2.53E-02	9.41E-05	7.53E-05
Fluoranthene	4.39E-01	7.07E-01	4.95E-04	3.96E-04
Fluorene	1.38E-02	2.22E-02	1.56E-05	1.25E-05
Hexachlorobenzene	2.90E-01	8.29E-03	9.99E-05	7.99E-05
Phenanthrene	2.80E-01	4.51E-01	3.16E-04	2.53E-04
Pyrene	4.82E-01	7.76E-01	5.44E-04	4.35E-04
LPAH	1.77E+02	5.47E-01	5.87E-02	4.70E-02
HPAH	1.11E+00	3.02E+00	1.86E-03	1.49E-03
TOTAL PAHs	6.14E+00	3.57E+00	3.80E-03	3.04E-03

TOTAL INTAKE

INTAKE = Sediment Intake + Surface Water Intake + Food Intake

Chemical	Total Intake	Total Intake - Refined
4,4'-DDT	1.10E-06	8.76E-07
Acenaphthene	1.74E-05	1.39E-05
Benzo(a)anthracene	1.09E-04	8.69E-05
Chrysene	2.79E-04	2.23E-04
Dibenz(a,h)anthracene	9.66E-05	7.73E-05
Fluoranthene	5.64E-04	4.51E-04
Fluorene	1.77E-05	1.42E-05
Hexachlorobenzene	1.02E-04	8.20E-05
Phenanthrene	3.60E-04	2.88E-04
Pyrene	6.20E-04	4.96E-04
LPAH	5.87E-02	4.70E-02
HPAH	2.16E-03	1.73E-03
TOTAL PAHs	4.14E-03	3.32E-03

NOTES:
Shaded rows are the exposure parameters to be used in the Refinement Step 3a of the ERA process. Ingestion rate equations, inclusive of body weight, are the same as those used in pre-Refinement calculations.
* Total Intake for the COPEC includes all three exposure pathways.
** COPEC was measured in crab tissue and water, but not in sediment.

TABLE E-5
INTAKE CALCULATIONS FOR INTRACOASTAL WATERWAY SEDIMENT
Avian Carnivore (GREEN HERON)

SEDIMENT INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Sediment concentration (mg/kg)	see Table F-1	
IR - refined	Mean Ingestion rate of sed (kg/day)***	1.88E-06	EPA, 1993
IR	Maximum Ingestion rate of sed (kg/day)***	1.88E-06	EPA, 1993
AF	Chemical Bioavailability in sediment (unitless)	1	EPA, 1997
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	2.12E-01	EPA, 1993
BW	Minimum Body weight (kg)	1.77E-01	EPA, 1993

Chemical	Sc	Intake	Intake - Refined
4,4'-DDT	2.03E-04	2.16E-09	1.80E-09
Acenaphthene	1.35E-02	1.43E-07	1.20E-07
Benzo(a)anthracene	1.38E-02	1.47E-07	1.22E-07
Chrysene	2.73E-01	2.90E-06	2.42E-06
Dibenz(a,h)anthracene	1.57E-02	1.67E-07	1.39E-07
Fluoranthene	4.39E-01	4.66E-06	3.89E-06
Fluorene	1.38E-02	1.47E-07	1.22E-07
Hexachlorobenzene	1.62E-02	1.72E-07	1.43E-07
Phenanthrene	2.80E-01	2.97E-06	2.48E-06
Pyrene	4.82E-01	5.12E-06	4.27E-06
LPAH	3.40E-01	3.61E-06	3.01E-06
HPAH	1.88E+00	1.99E-05	1.66E-05
TOTAL PAHs	2.22E+00	2.35E-05	1.96E-05

FOOD INGESTION

INTAKE = ((Cc * IR * Dfc * AUF)/(BW) + (Cw * IR * DFw * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Cc	Crab concentration (mg/kg)	see Table F-8	
Cw	Worm concentration (mg/kg)	see Table F-8	
IR - refined	Mean Ingestion rate of food (kg/day)***	9.40E-05	EPA, 1993
IR	Maximum Ingestion rate of of food (kg/day)***	9.40E-05	EPA, 1993
Dfc	Dietary fraction of crabs (unitless)	2.50E-01	Kent, 1986
Dff	Dietary fraction of fish (unitless)	7.50E-01	Kent, 1986
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	2.12E-01	EPA, 1993
BW	Minimum Body weight (kg)	1.77E-01	EPA, 1993

Chemical	Crab	Fish	Intake	Intake - Refined
4,4'-DDT	2.98E-03	1.18E-04	4.42E-07	3.68E-07
Acenaphthene	1.35E-02	6.68E-03	4.45E-06	3.71E-06
Benzo(a)anthracene	2.92E-01	9.11E-03	4.24E-05	3.53E-05
Chrysene	1.49E-01	1.80E-01	9.15E-05	7.63E-05
Dibenz(a,h)anthracene	2.47E-01	1.04E-02	3.69E-05	3.08E-05
Fluoranthene	4.39E-01	2.90E-01	1.74E-04	1.45E-04
Fluorene	1.38E-02	6.83E-03	4.55E-06	3.80E-06
Hexachlorobenzene	2.90E-01	2.30E-02	4.76E-05	3.97E-05
Phenanthrene	2.80E-01	1.39E-01	9.23E-05	7.70E-05
Pyrene	4.82E-01	3.18E-01	1.91E-04	1.59E-04
LPAH	1.77E+02	1.68E-01	2.35E-02	1.96E-02
HPAH	1.11E+00	1.24E+00	6.41E-04	5.34E-04
TOTAL PAHs	6.14E+00	1.46E+00	1.40E-03	1.17E-03

TOTAL INTAKE

INTAKE = Sediment Intake + Surface Water Intake + Food Intake

Chemical	Total Intake	Total Intake - Refined
4,4'-DDT	4.44E-07	3.70E-07
Acenaphthene	4.60E-06	3.83E-06
Benzo(a)anthracene	4.25E-05	3.55E-05
Chrysene	9.44E-05	7.87E-05
Dibenz(a,h)anthracene	3.71E-05	3.09E-05
Fluoranthene	1.78E-04	1.49E-04
Fluorene	4.70E-06	3.92E-06
Hexachlorobenzene	4.78E-05	3.99E-05
Phenanthrene	9.53E-05	7.95E-05
Pyrene	1.96E-04	1.63E-04
LPAH	2.35E-02	1.96E-02
HPAH	6.61E-04	5.51E-04
TOTAL PAHs	1.42E-03	1.18E-03

NOTES:
Shaded rows are the exposure parameters to be used in the Refinement Step 3a of the ERA process. Ingestion rate equations, inclusive of body weight, are the same as those used in pre-Refinement calculations.
* Total Intake for the COPEC includes all three exposure pathways.
** COPEC was measured in crab tissue and water, but not in sediment.
***Expressed in dry weight.

TABLE E-6
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR INTRACOASTAL WATERWAY SEDIMENT
Avian Carnivore (SANDPIPER)

Ecological Hazard Quotient = Total Intake / TRV

Parameter	Definition	Default
Total Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table F-2

Chemical	Total Intake	Total Intake - Refined	TRV Sandpiper		EHQ	EHQ - Refined
4,4'-DDT	1.10E-06	8.76E-07	2.27E-01	<	4.83E-06	3.86E-06
Acenaphthene	1.74E-05	1.39E-05				
Benzo(a)anthracene	1.09E-04	8.69E-05				
Chrysene	2.79E-04	2.23E-04				
Dibenz(a,h)anthracene	9.66E-05	7.73E-05				
Fluoranthene	5.64E-04	4.51E-04				
Fluorene	1.77E-05	1.42E-05				
Hexachlorobenzene	1.02E-04	8.20E-05	2.25E-01	<	4.55E-04	3.64E-04
Phenanthrene	3.60E-04	2.88E-04				
Pyrene	6.20E-04	4.96E-04				
LPAH	5.87E-02	4.70E-02				
HPAH	2.16E-03	1.73E-03				
TOTAL PAHs	4.14E-03	3.32E-03				

NOTES:
* Total Intake for the COPEC includes surface water exposure pathway.

TABLE E-7
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR INTRACOASTAL WATERWAY SEDIMENT
Avian Carnivore (GREEN HERON)

Ecological Hazard Quotient = Total Intake / TRV

Parameter	Definition	Default
Total Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table F-2

Chemical	Total Intake	Total Intake - Refined	TRV Green Heron		EHQ	EHQ - Refined
4,4'-DDT	4.44E-07	3.70E-07	2.27E-01	<	1.96E-06	1.63E-06
Acenaphthene	4.60E-06	3.83E-06				
Benzo(a)anthracene	4.25E-05	3.55E-05				
Chrysene	9.44E-05	7.87E-05				
Dibenz(a,h)anthracene	3.71E-05	3.09E-05				
Fluoranthene	1.78E-04	1.49E-04				
Fluorene	4.70E-06	3.92E-06				
Hexachlorobenzene	4.78E-05	3.99E-05	2.25E-01	<	2.13E-04	1.77E-04
Phenanthrene	9.53E-05	7.95E-05				
Pyrene	1.96E-04	1.63E-04				
LPAH	2.35E-02	1.96E-02				
HPAH	6.61E-04	5.51E-04				
TOTAL PAHs	1.42E-03	1.18E-03				

NOTES:
* Total Intake for the COPEC includes all three exposure pathways.

TABLE E-8
CONCENTRATION OF CHEMICAL IN FOOD ITEM (mg/kg)

Cfood = Csed x BSAF or Cwtr x BCF

where:

Cfood =	Chemical Concentration in food (mg/kg dry)
Csed =	Chemical Concentration in sediment (mg/kg dry)
Cwtr =	Chemical Concentration in water (mg/L)
BCF =	Bioconcentration Factor (unitless)

Compound	Csed (mg/kg)	Sediment to Worm BSAF	Worm Concentration	Reference	Sediment to Crab BSAF	Crab Concentration	Reference	Sediment to Fish BSAF	Fish Concentration	Reference
4,4'-DDT	2.03E-04	8.00E-01	1.62E-04	BSAF DB *		2.98E-03	*	5.80E-01	1.18E-04	WSDOH, 1995
Acenaphthene	1.35E-02	1.61E+00	2.17E-02	EPA, 1999	1.00E+00	1.35E-02	**	4.950E-01	6.68E-03	WSDOH, 1995
Benzo(a)anthracene	1.38E-02	1.45E+00	2.00E-02	EPA, 1999 *		2.92E-01	*	6.60E-01	9.11E-03	WSDOH, 1995
Chrysene	2.73E-01	1.38E+00	3.77E-01	EPA, 1999 *		1.49E-01	*	6.60E-01	1.80E-01	WSDOH, 1995
Dibenz(a,h)anthracene	1.57E-02	1.61E+00	2.53E-02	EPA, 1999 *		2.47E-01	*	6.60E-01	1.04E-02	WSDOH, 1995
Fluoranthene	4.39E-01	1.61E+00	7.07E-01	EPA, 1999	1.00E+00	4.39E-01	**	6.60E-01	2.90E-01	WSDOH, 1995
Fluorene	1.38E-02	1.61E+00	2.22E-02	EPA, 1999	1.00E+00	1.38E-02	**	4.95E-01	6.83E-03	WSDOH, 1995
Hexachlorobenzene	1.62E-02	5.12E-01	8.29E-03	BSAF DB *		2.90E-01	*	1.42E+00	2.30E-02	Max value from Calcasieu RI
Phenanthrene	*2.80E-01*	*1.61E+00*	*4.51E-01*	*EPA, 1999*	*1.00E+00*	*2.80E-01*	**	4.95E-01	1.39E-01	WSDOH, 1995
Pyrene	4.82E-01	1.61E+00	7.76E-01	EPA, 1999	1.00E+00	4.82E-01	**	6.60E-01	3.18E-01	WSDOH, 1995
LPAH	3.40E-01	1.61E+00	5.47E-01	EPA, 1999	3.27E+00	1.77E+02	max PAH	4.96E-01	1.68E-01	WSDOH, 1995
HPAH	1.88E+00	1.61E+00	3.02E+00	EPA, 1999	3.27E+00	1.11E+00	max PAH	6.60E-01	1.24E+00	WSDOH, 1995
TOTAL PAHs	2.22E+00	1.61E+00	3.57E+00	EPA, 1999	3.27E+00	6.14E+00	max PAH	6.60E-01	1.46E+00	WSDOH, 1995

Notes:
* These compounds were analyzed but not detected in any blue crab samples collected at the Site; so value is one-half of maximum detection limit.
*+ These compounds were not included in crab tissue analysis per the approved Sampling & Analysis Plan.
** If no BAF or BCF was available in the literature, a default value of 1.0 was used.
*** COPEC was measured in crab tissue and surface water, but not in sediment.

TABLE E-9
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR INTRACOASTAL WATERWAY SEDIMENT
Polychaetes -- COMPARED WITH MIDPOINT BETWEEN ERLs and ERMs

Ecological Hazard Quotient = Sc/TRV

Parameter	Definition	Default
Sc	Sediment Concentration (mg/kg)	see below
TRV	Toxicity Reference Value (mg/kg)	see Table F-2

Chemical	Exposure Point Concentration* (Sc)	TRV polychaete	Maximum EHQ
4,4'-DDT	3.32E-03	3.20E-02	1.04E-01
Acenaphthene	6.31E-02	3.42E-01	1.85E-01
Benzo(a)anthracene	3.95E-01	9.31E-01	4.25E-01
Chrysene	4.75E-01	1.59E+00	2.98E-01
Dibenz(a,h)anthracene	2.35E-01	1.62E-01	1.45E+00
Fluoranthene	8.04E-01	2.85E+00	2.82E-01
Fluorene	4.60E-02	2.80E-01	1.65E-01
Hexachlorobenzene	3.19E-02	6.00E-03	5.32E+00
Phenanthrene	5.08E-01	8.70E-01	5.84E-01
Pyrene	8.62E-01	1.63E+00	5.28E-01
LPAH	7.11E-01	1.86E+00	3.83E-01
HPAH	4.91E+00	5.65E+00	8.69E-01
TOTAL PAHs	5.62E+00	2.44E+01	2.30E-01

Notes:
*EPC for benthic receptors is maximum measured concentration.

APPENDIX F

ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR WETLAND SEDIMENT

TABLE F-1
EXPOSURE POINT CONCENTATION (mg/kg)
SEDIMENT NORTH OF MARLIN

Parameter		Exposure Point Concentration	Statistic Used
SEDIMENT			
2-Methylnaphthalene	<	1.20E-02	median
4,4'-DDT		2.52E-03	97.5% KM (Chebyshev)
Acenaphthene	<	1.10E-02	median
Acenaphthylene	<	1.27E-02	median
Anthracene		9.70E-02	97.5% KM (Chebyshev)
Arsenic		4.81E+00	97.5% Chebyshev
Benzo(a)anthracene	<	1.14E-02	median
Benzo(a)pyrene		3.47E-01	97.5% Chebyshev
Benzo(g,h,i)perylene		4.49E-01	95% KM (BCA)
Chrysene		8.71E-01	97.5% Chebyshev
Copper		2.21E+01	97.5% Chebyshev
Dibenz(a,h)anthracene	<	3.75E-02	median
Endrin Aldehyde		3.32E-03	97.5% Chebyshev
Endrin Ketone	<	5.50E-04	median
Fluoranthene		4.46E-01	97.5% Chebyshev
Fluorene	<	1.10E-02	median
gamma-Chlordane	<	4.40E-04	median
Indeno(1,2,3-cd)pyrene		3.17E-01	95% KM (BCA)
Lead		4.68E+01	95% Chebyshev
Nickel		1.81E+01	95% Student's-t
Phenanthrene		1.56E-01	95% KM (BCA)
Pyrene		4.71E-01	97.5% Chebyshev
Zinc		2.36E+02	95% Chebyshev
LPAH		3.00E-01	
HPAH		3.24E+00	
TOTAL PAHs		3.54E+00	

TABLE F-2
TOXICITY REFERENCE VALUES

Parameter	Polychaetes (mg/kg)	Ref.	Comments	Polychaetes (mg/kg)	Ref.	Comments	Avian Carnivore (Sandpiper) (mg/kgBW-day)	Ref.	Comments	Avian Carnivore (Green heron) (mg/kgBW-day)	Ref.	Comments
2-Methylnaphthalene	7.00E-02	SQUIRT	ERL	6.70E-01	SQUIRT	ERM						
4,4'-DDT	1.19E-03	SQUIRT	ERL	6.29E-02	SQUIRT	ERM	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
Acenaphthene	1.60E-02	SQUIRT	ERL	5.00E-01	SQUIRT	ERM						
Acenaphthylene	4.40E-02	SQUIRT	ERL	6.40E-01	SQUIRT	ERM						
Anthracene	8.53E-02	SQUIRT	ERL	1.10E+00	SQUIRT	ERM						
Arsenic	8.20E+00	SQUIRT	ERL	7.00E+01	SQUIRT	ERM						
Benzo(a)anthracene	2.61E-01	SQUIRT	ERL	1.60E+00	SQUIRT	ERM						
Benzo(a)pyrene	4.30E-01	SQUIRT	ERL	1.60E+00	SQUIRT	ERM						
Benzo(g,h,i)perylene	6.70E-01	SQUIRT	AET	6.70E-01	SQUIRT	AET						
Chrysene	3.84E-01	SQUIRT	ERL	2.80E+00	SQUIRT	ERM						
Copper	3.40E+01	SQUIRT	ERL	2.70E+02	SQUIRT	ERM	4.05E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	4.05E+00	EPA, 2007c	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
Dibenz(a,h)anthracene	6.34E-02	SQUIRT	ERL	2.60E-01	SQUIRT	ERM						
Endrin Aldehyde	2.67E-03	SQUIRT	TEL for freshwater sediment	6.24E-02	SQUIRT	PEL for freshwater sediment	1.00E-02	Sample, 1996	Chronic LOAEL in screech owl with an uncertainty factor of 0.1	1.00E-02	Sample, 1996	Chronic LOAEL in screech owl with an uncertainty factor of 0.1
Endrin Ketone	2.67E-03	SQUIRT	TEL for freshwater sediment	6.24E-02	SQUIRT	PEL for freshwater sediment	1.00E-02	Sample, 1996	Chronic LOAEL in screech owl with an uncertainty factor of 0.1	1.00E-02	Sample, 1996	Chronic LOAEL in screech owl with an uncertainty factor of 0.1
Fluoranthene	6.00E-01	SQUIRT	ERL	5.10E+00	SQUIRT	ERM						
Fluorene	1.90E-02	SQUIRT	ERL	5.40E-01	SQUIRT	ERM						
gamma-Chlordane	2.60E-03	SQUIRT	ERL	4.79E-03	SQUIRT	ERM	2.14E+00	Sample, 1996	Chronic NOAEL in red-winged blackbird	2.14E+00	Sample, 1996	Chronic NOAEL in red-winged blackbird
Indeno(1,2,3-cd)pyrene	6.00E-01	SQUIRT	AET	6.00E-01	SQUIRT	AET						
Lead	4.67E+01	SQUIRT	ERL	2.18E+02	SQUIRT	ERM	1.63E+00	EPA, 2005e	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	1.63E+00	EPA, 2005e	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
Nickel	2.09E+01	SQUIRT	ERL	5.16E+01	SQUIRT	ERM	6.71E+00	EPA, 2007d	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	6.71E+00	EPA, 2007d	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
Phenanthrene	2.40E-01	SQUIRT	ERL	1.50E+00	SQUIRT	ERM						
Pyrene	6.65E-01	SQUIRT	ERL	2.60E+00	SQUIRT	ERM						
Zinc	1.50E+02	SQUIRT	ERL	4.10E+02	SQUIRT	ERM	6.61E+01	EPA, 2007e	Geometric mean of NOAEL values within the reproductive and growth effect groups	6.61E+01	EPA, 2007e	Geometric mean of NOAEL values within the reproductive and growth effect groups
LPAH	5.52E-01	SQUIRT	ERL	3.16E+00	SQUIRT	ERM						
HPAH	1.70E+00	SQUIRT	ERL	9.60E+00	SQUIRT	ERM						
TOTAL PAHs	4.02E+00	SQUIRT	ERL	4.48E+01	SQUIRT	ERM						

Notes:
ERL – Effects Range-Low
AET – *Apparent Effects Threshold*
TEL – Threshold Effects Level
PEL – Probably Effects Level
EPA, 2007a – DDT
EPA, 2007b – PAHs
EPA, 2007d – Nickel
EPA, 2007c – Copper
EPA, 2007e – Zinc
EPA, 2005e – Lead

TABLE F-3
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SEDIMENT NORTH OF MARLIN
POLYCHAETES

Ecological Hazard Quotient = Sc/TRV

Parameter	Definition	Default
Sc	Sediment Concentration (mg/kg)	see below
TRV	Toxicity Reference Value (mg/kg)	see Table H-2

Chemical	Exposure Point Concentration* (Sc)	TRV polychaetes	Maximum EHQ+
2-Methylnaphthalene	4.30E-01	7.00E-02	6.14E+00
4,4'-DDT	9.22E-03	1.19E-03	7.75E+00
Acenaphthene	1.33E-01	1.60E-02	8.31E+00
Acenaphthylene	5.45E-01	4.40E-02	1.24E+01
Anthracene	3.34E-01	8.53E-02	3.92E+00
Arsenic	1.28E+01	8.20E+00	1.56E+00
Benzo(a)anthracene	9.93E-01	2.61E-01	3.80E+00
Benzo(a)pyrene	1.30E+00	4.30E-01	3.02E+00
Benzo(g,h,i)perylene	1.94E+00	6.70E-01	2.90E+00
Chrysene	4.05E+00	3.84E-01	1.05E+01
Copper	4.90E+01	3.40E+01	1.44E+00
Dibenz(a,h)anthracene	2.91E+00	6.34E-02	4.59E+01
Endrin Aldehyde	1.00E-02	2.67E-03	3.75E+00
Endrin Ketone	1.30E-02	2.67E-03	4.87E+00
Fluoranthene	2.17E+00	6.00E-01	3.62E+00
Fluorene	1.39E-01	1.90E-02	7.32E+00
gamma-Chlordane	3.60E-03	2.60E-03	1.38E+00
Indeno(1,2,3-cd)pyrene	1.94E+00	6.00E-01	3.23E+00
Lead	2.37E+01	4.67E+01	5.07E-01
Nickel	2.77E+01	2.09E+01	1.33E+00
Phenanthrene	1.30E+00	2.40E-01	5.42E+00
Pyrene	1.64E+00	6.65E-01	2.47E+00
Zinc	9.03E+02	1.50E+02	6.02E+00
LPAH	1.15E+00	5.52E-01	2.08E+00
HPAH	1.39E+01	1.70E+00	8.19E+00
TOTAL PAHs	1.51E+01	4.02E+00	3.75E+00

Notes:
*EPC for benthic receptors is maximum measured concentration.
+Shading indicates HQ > 1.

TABLE F-4
INTAKE CALCULATIONS FOR SEDIMENT NORTH OF MARLIN
Avian Carnivore (SANDPIPER)

SEDIMENT INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Sediment concentration (mg/kg)	see Table H-1	
IR - refined	Mean Ingestion rate of sed (kg/day)**	5.34E-06	EPA, 1993
IR	Maximum Ingestion rate of sed (kg/day)**	5.34E-06	EPA, 1993
AF	Chemical Bioavailability in sediment (unitless)	1	EPA, 1997
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	4.25E-02	EPA, 1993
BW	Minimum Body weight (kg)	3.40E-02	EPA, 1993

Chemical	Sc	Intake	Intake - Refined
2-Methylnaphthalene	1.20E-02	1.88E-06	1.51E-06
4,4'-DDT	2.52E-03	3.96E-07	3.16E-07
Acenaphthene	1.10E-02	1.73E-06	1.38E-06
Acenaphthylene	1.27E-02	1.99E-06	1.59E-06
Anthracene	9.70E-02	1.52E-05	1.22E-05
Arsenic	4.81E+00	7.55E-04	6.04E-04
Benzo(a)anthracene	1.14E-02	1.78E-06	1.43E-06
Benzo(a)pyrene	3.47E-01	5.45E-05	4.36E-05
Benzo(g,h,i)perylene	4.49E-01	7.05E-05	5.64E-05
Chrysene	8.71E-01	1.37E-04	1.09E-04
Copper	2.21E+01	3.47E-03	2.78E-03
Dibenz(a,h)anthracene	3.75E-02	5.89E-06	4.71E-06
Endrin Aldehyde	3.32E-03	5.21E-07	4.17E-07
Endrin Ketone	5.50E-04	8.63E-08	6.91E-08
Fluoranthene	4.46E-01	7.00E-05	5.60E-05
Fluorene	1.10E-02	1.73E-06	1.38E-06
gamma-Chlordane	4.40E-04	6.91E-08	5.52E-08
Indeno(1,2,3-cd)pyrene	3.17E-01	4.98E-05	3.98E-05
Lead	4.68E+01	7.35E-03	5.88E-03
Nickel	1.81E+01	2.84E-03	2.27E-03
Phenanthrene	1.56E-01	2.45E-05	1.96E-05
Pyrene	4.71E-01	7.39E-05	5.91E-05
Zinc	2.36E+02	3.70E-02	2.96E-02
LPAH	3.00E-01	4.70E-05	3.76E-05
HPAH	3.24E+00	5.08E-04	4.07E-04
TOTAL PAHs	3.54E+00	5.56E-04	4.44E-04

FOOD INGESTION

INTAKE = ((Cc * IR * Dfc * AUF)/(BW) + (Cw * IR * DFw * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Cc	Crab concentration (mg/kg)	see Table H-8	
Cw	Worm concentration (mg/kg)	see Table H-8	
IR - refined	Mean Ingestion rate of food (kg/day)**	2.81E-05	EPA, 1993
IR	Maximum Ingestion rate of of food (kg/day)**	2.81E-05	EPA, 1993
Dfc	Dietary fraction of crabs (unitless)	4.00E-01	prof. judgement
Dfw	Dietary fraction of worms (unitless)	6.00E-01	prof. judgement
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	4.25E-02	EPA, 1993
BW	Minimum Body weight (kg)	3.40E-02	EPA, 1993

Chemical	Crab	Worm	Intake	Intake - Refined
2-Methylnaphthalene	1.20E-02	1.93E-02	1.35E-05	1.08E-05
4,4'-DDT	2.98E-03	2.02E-03	1.98E-06	1.59E-06
Acenaphthene	1.10E-02	1.77E-02	1.24E-05	9.93E-06
Acenaphthylene	1.27E-02	2.04E-02	1.43E-05	1.15E-05
Anthracene	3.17E-01	1.56E-01	1.82E-04	1.46E-04
Arsenic	4.81E+00	4.33E+00	3.74E-03	2.99E-03
Benzo(a)anthracene	2.92E-01	1.65E-02	1.05E-04	8.37E-05
Benzo(a)pyrene	1.80E-01	5.52E-01	3.33E-04	2.66E-04
Benzo(g,h,i)perylene	4.49E-01	7.23E-01	5.07E-04	4.05E-04
Chrysene	1.49E-01	1.20E+00	6.45E-04	5.16E-04
Copper *	2.21E+01	6.64E+00	1.06E-02	8.49E-03
Dibenz(a,h)anthracene	2.47E-01	6.04E-02	1.12E-04	8.92E-05
Endrin Aldehyde	3.32E-03	3.32E-03	2.74E-06	2.19E-06
Endrin Ketone	5.50E-04	5.50E-04	4.54E-07	3.63E-07
Fluoranthene	5.95E+00	7.18E-01	2.32E-03	1.86E-03
Fluorene	1.10E-02	1.77E-02	1.24E-05	9.93E-06
gamma-Chlordane	1.01E-03	2.59E-03	1.62E-06	1.29E-06
Indeno(1,2,3-cd)pyrene	1.18E-01	5.10E-01	2.92E-04	2.33E-04
Lead	9.50E-02	1.40E+00	7.27E-04	5.82E-04
Nickel	9.77E-01	1.63E+01	8.40E-03	6.72E-03
Phenanthrene	1.56E-01	2.51E-01	1.76E-04	1.41E-04
Pyrene	4.71E-01	7.58E-01	5.31E-04	4.25E-04
Zinc	2.69E+02	1.35E+02	1.56E-01	1.24E-01
LPAH	9.80E-01	4.83E-01	5.63E-04	4.50E-04
HPAH	1.06E+01	5.22E+00	6.09E-03	4.87E-03
TOTAL PAHs	1.16E+01	5.70E+00	6.65E-03	5.32E-03

TABLE F-4
INTAKE CALCULATIONS FOR SEDIMENT NORTH OF MARLIN
Avian Carnivore (SANDPIPER)

TOTAL INTAKE

INTAKE = Sediment Intake + Water Intake + Food Intake

Chemical	Total Intake	Total Intake - Refined
2-Methylnaphthalene	1.54E-05	1.23E-05
4,4'-DDT	2.38E-06	1.90E-06
Acenaphthene	1.41E-05	1.13E-05
Acenaphthylene	1.63E-05	1.31E-05
Anthracene	1.97E-04	1.58E-04
Arsenic	4.49E-03	3.59E-03
Benzo(a)anthracene	1.06E-04	8.51E-05
Benzo(a)pyrene	3.87E-04	3.10E-04
Benzo(g,h,i)perylene	5.77E-04	4.62E-04
Chrysene	7.82E-04	6.25E-04
Copper *	1.64E-02	1.31E-02
Dibenz(a,h)anthracene	1.17E-04	9.39E-05
Endrin Aldehyde	3.26E-06	2.61E-06
Endrin Ketone	5.41E-07	4.33E-07
Fluoranthene	2.39E-03	1.91E-03
Fluorene	1.41E-05	1.13E-05
gamma-Chlordane	1.69E-06	1.35E-06
Indeno(1,2,3-cd)pyrene	3.42E-04	2.73E-04
Lead	8.07E-03	6.46E-03
Nickel *	1.17E-02	9.36E-03
Phenanthrene	2.01E-04	1.60E-04
Pyrene	6.05E-04	4.84E-04
Zinc *	1.97E-01	1.58E-01
LPAH	6.10E-04	4.88E-04
HPAH	6.59E-03	5.28E-03
TOTAL PAHs	7.20E-03	5.76E-03

NOTES:
Shaded rows are the exposure parameters to be used in the Refinement Step 3a of the ERA process. Ingestion rate equations, inclusive of body weight, are the same as those used in pre-Refinement calculations.
* Total Intake for the COPEC includes all three exposure pathways.
**Ingestion rates are in dry weight.

TABLE F-5
INTAKE CALCULATIONS FOR SEDIMENT NORTH OF MARLIN
Avian Carnivore (GREEN HERON)

SEDIMENT INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Sediment concentration (mg/kg)	see Table H-1	
IR - refined	Mean Ingestion rate of sed (kg/day)**	1.88E-06	EPA, 1993
IR	Maximum Ingestion rate of sed (kg/day)**	1.88E-06	EPA, 1993
AF	Chemical Bioavailability in sediment (unitless)	1	EPA, 1997
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	2.12E-01	EPA, 1993
BW	Minimum Body weight (kg)	1.77E-01	EPA, 1993

Chemical	Sc	Intake	Intake - Refined
2-Methylnaphthalene	1.20E-02	1.27E-07	1.06E-07
4,4'-DDT	2.52E-03	2.68E-08	2.23E-08
Acenaphthene	1.10E-02	1.17E-07	9.74E-08
Acenaphthylene	1.27E-02	1.35E-07	1.12E-07
Anthracene	9.70E-02	1.03E-06	8.59E-07
Arsenic	4.81E+00	5.11E-05	4.26E-05
Benzo(a)anthracene	1.14E-02	1.21E-07	1.01E-07
Benzo(a)pyrene	3.47E-01	3.68E-06	3.07E-06
Benzo(g,h,i)perylene	4.49E-01	4.77E-06	3.98E-06
Chrysene	8.71E-01	9.25E-06	7.71E-06
Copper	2.21E+01	2.35E-04	1.96E-04
Dibenz(a,h)anthracene	3.75E-02	3.98E-07	3.32E-07
Endrin Aldehyde	3.32E-03	3.52E-08	2.94E-08
Endrin Ketone	5.50E-04	5.84E-09	4.87E-09
Fluoranthene	4.46E-01	4.74E-06	3.95E-06
Fluorene	1.10E-02	1.17E-07	9.74E-08
gamma-Chlordane	4.40E-04	4.67E-09	3.90E-09
Indeno(1,2,3-cd)pyrene	3.17E-01	3.37E-06	2.81E-06
Lead	4.68E+01	4.97E-04	4.14E-04
Nickel	1.81E+01	1.92E-04	1.60E-04
Phenanthrene	1.56E-01	1.66E-06	1.38E-06
Pyrene	4.71E-01	5.00E-06	4.17E-06
Zinc	2.36E+02	2.51E-03	2.09E-03
LPAH	3.00E-01	3.18E-06	2.65E-06
HPAH	3.24E+00	3.44E-05	2.87E-05
TOTAL PAHs	3.54E+00	3.76E-05	3.13E-05

FOOD INGESTION

INTAKE = ((Cc * IR * Dfc * AUF)/(BW) + (Cw * IR * DFf * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Cc	Crab concentration (mg/kg)	see Table H-8	
Cw	Worm concentration (mg/kg)	see Table H-8	
IR - refined	Mean Ingestion rate of food (kg/day)**	9.40E-05	EPA, 1993
IR	Ingestion rate of of food (kg/day)**	9.40E-05	EPA, 1993
Dfc	Dietary fraction of crabs (unitless)	2.50E-01	Kent, 1986
Dff	Dietary fraction of fish (unitless)	7.50E-01	Kent, 1986
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	2.12E-01	EPA, 1993
BW	Minimum Body weight (kg)	1.77E-01	EPA, 1993

Chemical	Crab	Fish	Intake	Intake - Refined
2-Methylnaphthalene	1.20E-02	5.58E-02	2.38E-05	1.99E-05
4,4'-DDT	2.98E-03	1.46E-03	9.77E-07	8.15E-07
Acenaphthene	1.10E-02	5.45E-03	3.63E-06	3.03E-06
Acenaphthylene	1.27E-02	6.29E-03	4.19E-06	3.49E-06
Anthracene	3.17E-01	8.15E-03	4.53E-05	3.78E-05
Arsenic	4.81E+00	7.80E-01	9.49E-04	7.92E-04
Benzo(a)anthracene	2.92E-01	7.49E-03	4.17E-05	3.48E-05
Benzo(a)pyrene	1.80E-01	2.29E-01	1.15E-04	9.59E-05
Benzo(g,h,i)perylene	4.49E-01	2.96E-01	1.78E-04	1.48E-04
Chrysene	1.49E-01	5.75E-01	2.49E-04	2.07E-04
Copper	2.21E+01	2.21E+01	1.18E-02	9.80E-03
Dibenz(a,h)anthracene	2.47E-01	2.48E-02	4.26E-05	3.56E-05
Endrin Aldehyde	3.32E-03	3.32E-03	1.76E-06	1.47E-06
Endrin Ketone	5.50E-04	5.50E-04	2.92E-07	2.44E-07
Fluoranthene	5.95E+00	2.94E-01	9.07E-04	7.56E-04
Fluorene	1.10E-02	5.45E-03	3.63E-06	3.03E-06
gamma-Chlordane	1.01E-03	6.60E-04	3.97E-07	3.31E-07
Indeno(1,2,3-cd)pyrene	1.18E-01	2.09E-01	9.89E-05	8.25E-05
Lead	9.50E-02	9.36E-01	3.85E-04	3.21E-04
Nickel	9.77E-01	9.77E-01	5.19E-04	4.33E-04
Phenanthrene	1.56E-01	7.72E-02	5.14E-05	4.29E-05
Pyrene	4.71E-01	3.11E-01	1.86E-04	1.55E-04
Zinc	2.69E+02	2.69E+02	1.43E-01	1.19E-01
LPAH	9.80E-01	1.48E-01	1.89E-04	1.58E-04
HPAH	1.06E+01	2.14E+00	2.26E-03	1.88E-03
TOTAL PAHs	1.16E+01	2.34E+00	2.47E-03	2.06E-03

TABLE F-5
INTAKE CALCULATIONS FOR SEDIMENT NORTH OF MARLIN
Avian Carnivore (GREEN HERON)

TOTAL INTAKE

INTAKE = Sediment Intake + Water Intake + Food Intake

Chemical	Total Intake	Total Intake - Refined
2-Methylnaphthalene	2.39E-05	2.00E-05
4,4'-DDT	1.00E-06	8.37E-07
Acenaphthene	3.74E-06	3.12E-06
Acenaphthylene	4.32E-06	3.61E-06
Anthracene	4.64E-05	3.87E-05
Arsenic	1.00E-03	8.34E-04
Benzo(a)anthracene	4.19E-05	3.49E-05
Benzo(a)pyrene	1.19E-04	9.90E-05
Benzo(g,h,i)perylene	1.82E-04	1.52E-04
Chrysene	2.58E-04	2.15E-04
Copper *	1.33E-02	1.11E-02
Dibenz(a,h)anthracene	4.30E-05	3.59E-05
Endrin Aldehyde	1.80E-06	1.50E-06
Endrin Ketone	2.98E-07	2.48E-07
Fluoranthene	9.12E-04	7.60E-04
Fluorene	3.74E-06	3.12E-06
gamma-Chlordane	4.02E-07	3.35E-07
Indeno(1,2,3-cd)pyrene	1.02E-04	8.53E-05
Lead	8.82E-04	7.36E-04
Nickel *	9.71E-04	8.10E-04
Phenanthrene	5.31E-05	4.43E-05
Pyrene	1.91E-04	1.60E-04
Zinc *	1.48E-01	1.23E-01
LPAH	1.92E-04	1.60E-04
HPAH	2.29E-03	1.91E-03
TOTAL PAHs	2.50E-03	2.09E-03

NOTES:
Shaded rows are the exposure parameters to be used in the Refinement Step 3a of the ERA process. Ingestion rate equations, inclusive of body weight, are the same as those used in pre-Refinement calculations.
* Total Intake for the COPEC includes all three exposure pathways.
**Ingestion rates are in dry weight.

TABLE F-6
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SEDIMENT NORTH OF MARLIN
Avian Carnivore (SANDPIPER)

Ecological Hazard Quotient = Total Intake / TRV

Parameter	Definition	Default
Total Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table H-2

Chemical	Total Intake	Total Intake - Refined	TRV Sandpiper		EHQ	EHQ - Refined
2-Methylnaphthalene	1.54E-05	1.23E-05				
4,4'-DDT	2.38E-06	1.90E-06	2.27E-01		1.05E-05	8.38E-06
Acenaphthene	1.41E-05	1.13E-05				
Acenaphthylene	1.63E-05	1.31E-05				
Anthracene	1.97E-04	1.58E-04				
Arsenic	4.49E-03	3.59E-03				
Benzo(a)anthracene	1.06E-04	8.51E-05				
Benzo(a)pyrene	3.87E-04	3.10E-04				
Benzo(g,h,i)perylene	5.77E-04	4.62E-04				
Chrysene	7.82E-04	6.25E-04				
Copper	1.64E-02	1.31E-02	4.05E+00		4.05E-03	3.24E-03
Dibenz(a,h)anthracene	1.17E-04	9.39E-05				
Endrin Aldehyde	3.26E-06	2.61E-06	1.00E-02		3.26E-04	2.61E-04
Endrin Ketone	5.41E-07	4.33E-07	1.00E-02	<	5.41E-05	4.33E-05
Fluoranthene	2.39E-03	1.91E-03				
Fluorene	1.41E-05	1.13E-05				
gamma-Chlordane	1.69E-06	1.35E-06	2.14E+00	<	7.88E-07	6.30E-07
Indeno(1,2,3-cd)pyrene	3.42E-04	2.73E-04				
Lead	8.07E-03	6.46E-03	1.63E+00		4.95E-03	3.96E-03
Nickel	1.17E-02	9.36E-03	6.71E+00		1.74E-03	1.39E-03
Phenanthrene	2.01E-04	1.60E-04				
Pyrene	6.05E-04	4.84E-04				
Zinc	1.97E-01	1.58E-01	6.61E+01		2.98E-03	2.39E-03
LPAH	6.10E-04	4.88E-04				
HPAH	6.59E-03	5.28E-03				
TOTAL PAHs	7.20E-03	5.76E-03				

TABLE F-7
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SEDIMENT NORTH OF MARLIN
Avian Carnivore (GREEN HERON)

Ecological Hazard Quotient = Total Intake / TRV

Parameter	Definition	Default
Total Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table H-2

Chemical	Total Intake	Total Intake - Refined	TRV Green Heron		EHQ	EHQ - Refined
2-Methylnaphthalene	2.39E-05	2.00E-05				
4,4'-DDT	1.00E-06	8.37E-07	2.27E-01		4.42E-06	3.69E-06
Acenaphthene	3.74E-06	3.12E-06				
Acenaphthylene	4.32E-06	3.61E-06				
Anthracene	4.64E-05	3.87E-05				
Arsenic	1.00E-03	8.34E-04				
Benzo(a)anthracene	4.19E-05	3.49E-05				
Benzo(a)pyrene	1.19E-04	9.90E-05				
Benzo(g,h,i)perylene	1.82E-04	1.52E-04				
Chrysene	2.58E-04	2.15E-04				
Copper	1.33E-02	1.11E-02	4.05E+00		3.28E-03	2.74E-03
Dibenz(a,h)anthracene	4.30E-05	3.59E-05				
Endrin Aldehyde	1.80E-06	1.50E-06	1.00E-02		1.80E-04	1.50E-04
Endrin Ketone	2.98E-07	2.48E-07	1.00E-02	<	2.98E-05	2.48E-05
Fluoranthene	9.12E-04	7.60E-04				
Fluorene	3.74E-06	3.12E-06				
gamma-Chlordane	4.02E-07	3.35E-07	2.14E+00	<	1.88E-07	1.57E-07
Indeno(1,2,3-cd)pyrene	1.02E-04	8.53E-05				
Lead	8.82E-04	7.36E-04	1.63E+00		5.41E-04	4.51E-04
Nickel	9.71E-04	8.10E-04	6.71E+00		1.45E-04	1.21E-04
Phenanthrene	5.31E-05	4.43E-05				
Pyrene	1.91E-04	1.60E-04				
Zinc	1.48E-01	1.23E-01	6.61E+01		2.24E-03	1.87E-03
LPAH	1.92E-04	1.60E-04				
HPAH	2.29E-03	1.91E-03				
TOTAL PAHs	2.50E-03	2.09E-03				

TABLE F-8
CONCENTRATION OF CHEMICAL IN FOOD ITEM (mg/kg)

Cfood = Csed x BSAF or Cwtr x BCF

where:

Cfood =	*Chemical Concentration in food (mg/kg dry)*
Csed =	Chemical Concentration in sediment (mg/kg dry)
Cwtr =	Chemical Concentration in water (mg/L)
BSAF	Biota to Sediment Accumulation Factor (unitless)
BCF =	Bioconcentration Factor (unitless)

Compound	Csed (mg/kg)	Sediment to Worm BSAF	Worm Concentration	Reference	Sediment to Crab BSAF	Crab Concentration	Reference	Sediment to Fish BSAF	Fish Concentration	Reference
2-Methylnaphthalene	1.20E-02	1.61E+00	1.93E-02	EPA, 1999	1.00E+00	1.20E-02	**	4.65E+00	5.58E-02	Brunson et al. (1998)
4,4'-DDT	2.52E-03	8.00E-01	2.02E-03	BSAF DB *		2.98E-03	*	5.80E-01	1.46E-03	WSDOH, 1995
Acenaphthene	1.10E-02	1.61E+00	1.77E-02	EPA, 1999	1.00E+00	1.10E-02	**	4.95E-01	5.45E-03	WSDOH, 1995
Acenaphthylene	1.27E-02	1.61E+00	2.04E-02	EPA, 1999	1.00E+00	1.27E-02	**	4.95E-01	6.29E-03	WSDOH, 1995
Anthracene	9.70E-02	1.61E+00	1.56E-01	EPA, 1999	3.27E+00	3.17E-01	BSAF DB	8.40E-02	8.15E-03	WSDOH, 1995
Arsenic	4.81E+00	9.00E-01	4.33E+00	EPA, 1999	1.00E+00	4.81E+00	**	1.62E-01	7.80E-01	EPA, 2000
Benzo(a)anthracene	1.14E-02	1.45E+00	1.65E-02	EPA, 1999 *		2.92E-01	*	6.60E-01	7.49E-03	WSDOH, 1995
Benzo(a)pyrene	3.47E-01	1.59E+00	5.52E-01	EPA, 1999 *		1.80E-01	*	6.60E-01	2.29E-01	WSDOH, 1995
Benzo(g,h,i)perylene	4.49E-01	1.61E+00	7.23E-01	EPA, 1999	1.00E+00	4.49E-01	**	6.60E-01	2.96E-01	WSDOH, 1995
Chrysene	8.71E-01	1.38E+00	1.20E+00	EPA, 1999 *		1.49E-01	*	6.60E-01	5.75E-01	WSDOH, 1995
Copper	2.21E+01	3.00E-01	6.64E+00	EPA, 1999	1.00E+00	2.21E+01	**	1.00E+00	2.21E+01	Max value from Calcasieu RI
Dibenz(a,h)anthracene	3.75E-02	1.61E+00	6.04E-02	EPA, 1999 *		2.47E-01	*	6.60E-01	2.48E-02	WSDOH, 1995
Endrin Aldehyde	3.32E-03	1.00E+00	3.32E-03	**	1.00E+00	3.32E-03	**	1.00E+00	3.32E-03	**
Endrin Ketone	5.50E-04	1.00E+00	5.50E-04	**	1.00E+00	5.50E-04	**	1.00E+00	5.50E-04	**
Fluoranthene	4.46E-01	1.61E+00	7.18E-01	EPA, 1999	1.33E+01	5.95E+00	BSAF DB	6.60E-01	2.94E-01	WSDOH, 1995
Fluorene	1.10E-02	1.61E+00	1.77E-02	EPA, 1999	1.00E+00	1.10E-02	**	4.95E-01	5.45E-03	WSDOH, 1995
gamma-Chlordane	4.40E-04	5.88E+00	2.59E-03	BSAF DB	2.30E+00	1.01E-03	BSAF DB	1.50E+00	6.60E-04	BSAF DB
Indeno(1,2,3-cd)pyrene	3.17E-01	1.61E+00	5.10E-01	EPA, 1999 *		1.18E-01	*	6.60E-01	2.09E-01	WSDOH, 1995
Lead	4.68E+01	3.00E-02	1.40E+00	EPA, 1999 *		9.50E-02	*	2.00E-02	9.36E-01	Max value from Calcasieu RI
Nickel	1.81E+01	9.00E-01	1.63E+01	EPA, 1999	5.40E-02	9.77E-01	Max value fr	5.40E-02	9.77E-01	Max value from Calcasieu RI
Phenanthrene	1.56E-01	1.61E+00	2.51E-01	EPA, 1999	1.00E+00	1.56E-01	**	4.95E-01	7.72E-02	WSDOH, 1995
Pyrene	4.71E-01	1.61E+00	7.58E-01	EPA, 1999	1.00E+00	4.71E-01	**	6.60E-01	3.11E-01	WSDOH, 1995
Zinc	2.36E+02	5.70E-01	1.35E+02	EPA, 1999	1.14E+00	2.69E+02	Max value fr	1.14E+00	2.69E+02	Max value from Calcasieu RI
LPAH	3.00E-01	1.61E+00	4.83E-01	EPA, 1999	3.27E+00	9.80E-01	max PAH	4.95E-01	1.48E-01	WSDOH, 1995
HPAH	3.24E+00	1.61E+00	5.22E+00	EPA, 1999	3.27E+00	1.06E+01	max PAH	6.60E-01	2.14E+00	WSDOH, 1995
TOTAL PAHs	3.54E+00	1.61E+00	5.70E+00	EPA, 1999	3.27E+00	1.16E+01	max PAH	6.60E-01	2.34E+00	WSDOH, 1995

Notes:
* These compounds were analyzed but not detected in any blue crab samples collected at the Site; so value is one-half of maximum detection limit.
*+ These compounds were not included in crab tissue analysis per the approved Sampling & Analysis Plan.
** If no BAF or BCF was available in the literature, a default value of 1.0 was used.
*** COPEC was measured in crab tissue and surface water, but not in sediment.

TABLE F-9
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR SEDIMENT NORTH OF MARLIN
POLYCHAETES -- MIDPOINT BETWEEN ERL AND ERM COMPARISON

Ecological Hazard Quotient = Sc/TRV

Parameter	Definition	Default
Sc	Sediment Concentration (mg/kg)	see below
TRV	Toxicity Reference Value (mg/kg)	see Table H-2

Chemical	Exposure Point Concentration* (Sc)	TRV polychaetes	Maximum EHQ+
2-Methylnaphthalene	4.30E-01	3.70E-01	1.16E+00
4,4'-DDT	9.22E-03	3.20E-02	2.88E-01
Acenaphthene	1.33E-01	2.58E-01	5.16E-01
Acenaphthylene	5.45E-01	3.42E-01	1.59E+00
Anthracene	3.34E-01	5.93E-01	5.64E-01
Arsenic	1.28E+01	3.91E+01	3.27E-01
Benzo(a)anthracene	9.93E-01	9.31E-01	1.07E+00
Benzo(a)pyrene	1.30E+00	1.02E+00	1.28E+00
Benzo(g,h,i)perylene	1.94E+00	6.70E-01	2.90E+00
Chrysene	4.05E+00	1.59E+00	2.54E+00
Copper	4.90E+01	1.52E+02	3.22E-01
Dibenz(a,h)anthracene	2.91E+00	1.62E-01	1.80E+01
Endrin Aldehyde	1.00E-02	3.25E-02	3.07E-01
Endrin Ketone	1.30E-02	3.25E-02	4.00E-01
Fluoranthene	2.17E+00	2.85E+00	7.61E-01
Fluorene	1.39E-01	2.80E-01	4.97E-01
gamma-Chlordane	3.60E-03	3.70E-03	9.74E-01
Indeno(1,2,3-cd)pyrene	1.94E+00	6.00E-01	3.23E+00
Lead	2.37E+01	1.32E+02	1.79E-01
Nickel	2.77E+01	3.63E+01	7.64E-01
Phenanthrene	1.30E+00	8.70E-01	1.49E+00
Pyrene	1.64E+00	1.63E+00	1.00E+00
Zinc	9.03E+02	2.80E+02	3.23E+00
LPAH	1.15E+00	1.86E+00	6.18E-01
HPAH	1.39E+01	5.65E+00	2.47E+00
TOTAL PAHs	1.51E+01	2.44E+01	6.18E-01

Notes:
*EPC for benthic receptors is maximum measured concentration.
+Shading indicates HQ > 1.

APPENDIX G

ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR POND SEDIMENT

TABLE G-1
EXPOSURE POINT CONCENTATION (mg/kg)
POND SEDIMENT

Parameter		Exposure Point Concentration	Statistic Used
SEDIMENT			
4,4'-DDT	<	1.10E-02	median
Zinc		9.61E+02	95% Chebyshev

TABLE G-2
TOXICITY REFERENCE VALUES

Parameter	Polychaetes (mg/kg)	Ref.	Comments	Polychaetes (mg/kg)	Ref.	Comments	Avian Carnivore (Sandpiper) (mg/kgBW-day)	Ref.	Comments	Avian Carnivore (Green heron) (mg/kgBW-day)	Ref.	Comments
4,4'-DDT	1.19E-03	SQUIRT	ERL	6.29E-02	SQUIRT	ERM	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival	2.27E-01	EPA, 2007a	Highest bounded NOAEL for growth and reproduction lower than the lowest bounded LOAEL for reproduction, growth, and survival
Zinc	1.50E+02	SQUIRT	ERL	4.10E+02	SQUIRT	ERM	6.61E+01	EPA, 2007e	Geometric mean of NOAEL values within the reproductive and growth effect groups	6.61E+01	EPA, 2007e	Geometric mean of NOAEL values within the reproductive and growth effect groups

Notes:
ERL – Effects Range-Low
AET – Apparent Effects Threshold
EPA, 2007a – DDT
EPA, 2007e – Zinc

TABLE G-3
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR POND SEDIMENT
POLYCHAETES

Ecological Hazard Quotient = Sc/TRV

Parameter	Definition	Default
Sc	Sediment Concentration (mg/kg)	see below
TRV	Toxicity Reference Value (mg/kg)	see Table I-2

Chemical	Exposure Point Concentration* (Sc)	TRV polychaetes	Maximum EHQ⁺
4,4'-DDT	1.57E-03	1.19E-03	1.32E+00
Zinc	9.99E+02	1.50E+02	6.66E+00

Notes:
*EPC for benthic receptors is maximum measured concentration.
⁺Shading indicates HQ > 1.

TABLE G-4
INTAKE CALCULATIONS FOR POND SEDIMENT
Avian Carnivore (SANDPIPER)

SEDIMENT INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Sediment concentration (mg/kg)	see Table I-1	
IR - refined	Mean Ingestion rate of sed (kg/day)***	5.34E-06	EPA, 1993
IR	Maximum Ingestion rate of sed (kg/day)***	5.34E-06	EPA, 1993
AF	Chemical Bioavailability in sediment (unitless)	1	EPA, 1997
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	4.25E-02	EPA, 1993
BW	Minimum Body weight (kg)	3.40E-02	EPA, 1993

Chemical	Sc	Intake	Intake - Refined
4,4'-DDT	1.10E-02	1.73E-06	1.38E-06
Zinc	9.61E+02	1.51E-01	1.21E-01

FOOD INGESTION

INTAKE = ((Cc * IR * Dfc * AUF)/(BW) + (Cw * IR * DFw * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Cc	Crab concentration (mg/kg)	see Table I-8	
Cw	Worm concentration (mg/kg)	see Table I-8	
IR - refined	Mean Ingestion rate of food (kg/day)***	2.81E-05	EPA, 1993
IR	Maximum Ingestion rate of of food (kg/day)***	2.81E-05	EPA, 1993
Dfc	Dietary fraction of crabs (unitless)	4.00E-01	prof. judgement
Dfw	Dietary fraction of worms (unitless)	6.00E-01	prof. judgement
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	4.25E-02	EPA, 1993
BW	Minimum Body weight (kg)	3.40E-02	EPA, 1993

Chemical	Crab	Worm	Intake	Intake - Refined
4,4'-DDT	2.98E-03	8.80E-03	5.34E-06	4.28E-06
Zinc	1.10E+03	5.48E+02	6.33E-01	5.07E-01

TOTAL INTAKE

INTAKE = Sediment Intake +Water Intake + Food Intake

Chemical	Total Intake	Total Intake - Refined
4,4'-DDT	7.07E-06	5.66E-06
Zinc *	9.16E-01	8.59E-01

NOTES:
Shaded rows are the exposure parameters to be used in the Refinement Step 3a of the ERA process. Ingestion rate equations, inclusive of body weight, are the same as those used in pre-Refinement calculations.
* Total Intake for the COPEC includes all three exposure pathways.
** COPEC was measured in crab tissue and water, but not in sediment.
*** Expressed in dry weight.

TABLE G-5
INTAKE CALCULATIONS FOR POND SEDIMENT
Avian Carnivore (GREEN HERON)

SEDIMENT INGESTION

INTAKE = (Sc * IR * AF * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Sc	Sediment concentration (mg/kg)	see Table I-1	
IR - refined	Mean Ingestion rate of sed (kg/day)***	1.88E-06	EPA, 1993
IR	Maximum Ingestion rate of sed (kg/day)***	1.88E-06	EPA, 1993
AF	Chemical Bioavailability in sediment (unitless)	1	EPA, 1997
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	2.12E-01	EPA, 1993
BW	Minimum Body weight (kg)	1.77E-01	EPA, 1993

Chemical	Sc	Intake	Intake - Refined
4,4'-DDT	1.10E-02	1.17E-07	9.74E-08
Zinc	9.61E+02	1.02E-02	8.51E-03

FOOD INGESTION

INTAKE = ((Cc * IR * Dfc * AUF)/(BW) + (Cw * IR * DFw * AUF) / (BW)

Parameter	Definition	Value	Reference
Intake	Intake of chemical (mg/kg-day)	calculated	
Cc	Crab concentration (mg/kg)	see Table I-8	
Cw	Worm concentration (mg/kg)	see Table I-8	
IR - refined	Mean Ingestion rate of food (kg/day)***	9.40E-05	EPA, 1993
IR	Maximum Ingestion rate of of food (kg/day)***	9.40E-05	EPA, 1993
Dfc	Dietary fraction of crabs (unitless)	2.50E-01	Kent, 1986
Dff	Dietary fraction of fish (unitless)	7.50E-01	Kent, 1986
AUF - refined	Refined Area Use Factor	1	EPA, 1993
AUF	Default Area Use Factor	1	EPA, 1997
BW - refined	Mean Body weight (kg)	2.12E-01	EPA, 1993
BW	Minimum Body weight (kg)	1.77E-01	EPA, 1993

Chemical	Crab	Fish	Intake	Intake - Refined
4,4'-DDT	2.98E-03	6.38E-03	2.93E-06	2.45E-06
Zinc	1.10E+03	1.10E+03	5.81E-01	4.85E-01

TOTAL INTAKE

INTAKE = Sediment Intake +Water Intake + Food Intake

Chemical	Total Intake	Total Intake - Refined
4,4'-DDT	3.05E-06	2.55E-06
Zinc *	6.66E-01	5.55E-01

NOTES:
Shaded rows are the exposure parameters to be used in the Refinement Step 3a of the ERA process. Ingestion rate equations, inclusive of body weight, are the same as those used in pre-Refinement calculations.
* Total Intake for the COPEC includes all three exposure pathways.
** COPEC was measured in crab tissue and water, but not in sediment.
*** Expressed in dry weight.

TABLE G-6
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR POND SEDIMENT
Avian Carnivore (SANDPIPER)

Ecological Hazard Quotient = Total Intake / TRV

Parameter	Definition	Default
Total Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table I-2

Chemical	Total Intake	Total Intake - Refined	TRV Sandpiper		EHQ	EHQ - Refined
4,4'-DDT	7.07E-06	5.66E-06	2.27E-01	<	3.11E-05	2.49E-05
Zinc	9.16E-01	8.59E-01	6.61E+01		1.39E-02	1.30E-02

TABLE G-7
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR POND SEDIMENT
Avian Carnivore (GREEN HERON)

Ecological Hazard Quotient = Total Intake / TRV

Parameter	Definition	Default
Total Intake	Intake of COPEC (mg/kg-day)	see Intake
TRV	Toxicity Reference Value (mg/kg)	see Table I-2

Chemical	Total Intake	Total Intake - Refined	TRV Green Heron		EHQ	EHQ - Refined
4,4'-DDT	3.05E-06	2.55E-06	2.27E-01	<	1.34E-05	1.12E-05
Zinc	6.66E-01	5.55E-01	6.61E+01		1.01E-02	8.40E-03

TABLE G-8
CONCENTRATION OF CHEMICAL IN FOOD ITEM (mg/kg)

Cfood = Csed x BSAF (or BSAF or BCF with food chain multiplier)

where:

Cfood =	Chemical Concentration in food (mg/kg dry)
Csed =	Chemical Concentration in soil (mg/kg dry)
BSAF	Biota to Sediment Accumulation Factor (unitless)
BCF =	Bioconcentration Factor (unitless)

Compound	Csed (mg/kg)	Sediment to Worm BSAF	Worm Concentration	Reference	Sediment to Crab BSAF	Crab Concentration	Reference	Sediment to Fish BSAF	Fish Concentration	Reference
4,4'-DDT	1.10E-02	8.00E-01	8.80E-03	BSAF DB	*	2.98E-03	*	5.80E-01	6.38E-03	WSDOH, 1995
Zinc	9.61E+02	5.70E-01	5.48E+02	EPA, 2003	1.14E+00	1.10E+03	Max value fr	1.14E+00	1.10E+03	Max value from Calcasieu RI

Notes:
* *These compounds were analyzed but not detected in any blue crab samples collected at the Site; so value is one-half of maximum detection limit.*
*+ These compounds were not included in crab tissue analysis per the approved Sampling & Analysis Plan.
** If no BAF or BCF was available in the literature, a default value of 1.0 was used.
*** COPEC was measured in crab tissue and surface water, but not in sediment.

TABLE G-9
ECOLOGICAL HAZARD QUOTIENT CALCULATIONS FOR POND SEDIMENT
POLYCHAETES -- MIDPOINT BETWEEN ERL AND ERM COMPARISON

Ecological Hazard Quotient = Sc/TRV

Parameter	Definition	Default
Sc	Sediment Concentration (mg/kg)	see below
TRV	Toxicity Reference Value (mg/kg)	see TRV summary page

Chemical	Exposure Point Concentration* (Sc)	TRV polychaetes	Maximum EHQ+
4,4'-DDT	1.57E-03	3.20E-02	4.90E-02
Zinc	9.99E+02	2.80E+02	3.57E+00

Notes:
*EPC for benthic receptors is maximum measured concentration.
+Shading indicates HQ > 1.

APPENDIX H

REFERENCES FOR THE APPENDICES

APPENDIX H – REFERENCES FOR APPENDICES

Bechtel Jacobs Company LLC. 1998. *Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants*. BJC/OR-133. Prepared for the U.S. Department of Energy, Office of Environmental Management. September. 116 pp.

Calder, WA, and EJ Braun, 1983. Scaling of osmotic regulation in mammals and birds. Am J Physiol. 224: Rr601-R606.

Cammen, L. 1979. Ingestion Rate: An Empirical Model for Aquatic Deposit Feeders and Detritivores. *Oecologia.* 44:303-310.

Davis, WB, and DJ Schmidley, 2009. *The Mammals of Texas, online edition*. www.nrsl.ttu.edu/tmotl/ . accessed December 14, 2009.

Dunning, Jr., JB. 1993. *CRC Handbook of Avian Body Masses*. CRC Press, Inc.: Boca Raton, Florida.

Kent, DM. 1986. Behavior, habitat use, and food of three egrets in a marine habitat. *Colonial Waterbirds*. 9:25-30.

Neill, 1998. Personal communication on March 13, 1998 as contained in Alcoa, 2000.

Sample, B.E., D.M. Opresko, and G.W. Suter II, 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.* Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter II, and C.J.E. Welsh, 1997. Methods and Tools for Estimation of the Expsoure of Terrestrial Wildlife to Contaminants. ORNL/TM-13391. Prepared for the U.S. Department of Energy, Office of Environmental Management by Oak Ridge National Laboratory. October.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter II. 1998a. *Development and Validation of Bioaccumulation Models for Small Mammals*. ES/ER/TM-219. Prepared for the U.S. Department of Energy, Office of Environmental Management by Oak Ridge National Laboratory. February. 92 pp.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter II, and T.L. Ashwood. 1998b. *Development and Validation of Bioaccumulation Models for Earthworms*. ES/ER/TM-220. Prepared for the U.S. Department of Energy, Office of Environmental Management by Oak Ridge National Laboratory. February. 53 pp.

Texas Parks and Wildlife Department (TPWD), 2005. Online database with endangered species listing. www.tpwd.state.tx.us/huntwild/wild/species/?c=endangered.

United States Army Corps of Engineers, (BSAF DB), 2010. BSAF online database. Engineer Research and Development Center, Environmental Laboratory. http://el.erdc.usace.army.mil/bsafnew/BSAF.html

United States Environmental Protection Agency (EPA), 1993. *Wildlife Exposure Factors Handbook, Volume I of II*. Office of Research and Development. EPA/600/R-93/187a.

United States Environmental Protection Agency (EPA), 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final.* Office of Solid Waste and Emergency Response. OSWER 9285.7-25. EPA 540-R-97-006. June.

United States Environmental Protection Agency (EPA), 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities.* Office of Solid Waste and Emergency Response. EPA530-D-99-001A. August.

United States Environmental Protection Agency (EPA), 2000. *Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins.* EPA Region 4, originally published November 1995, Website version last updated May 2000: http://www.epa.gov/region4/waste/oftecser/healtbul.htm.

United States Environmental Protection Agency (EPA), 2005a. *Ecological Soil Screening Levels for Antimony. Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-61. February.

United States Environmental Protection Agency (EPA), 2005b. *Ecological Soil Screening Levels for Cadmium. Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-65. March.

United States Environmental Protection Agency (EPA), 2005c. *Ecological Soil Screening Levels for Chromium. Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-66. March.

United States Environmental Protection Agency (EPA), 2005d. *Ecological Soil Screening Levels for Vanadium. Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-75. April.

United States Environmental Protection Agency (EPA), 2005e. *Ecological Soil Screening Levels for Lead. Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-70. March.

United States Environmental Protection Agency (EPA), 2005f. *Ecological Soil Screening Levels for Dieldrin. Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-56. March.

United States Environmental Protection Agency (EPA), 2005g. *Ecological Soil Screening Levels for Barium. Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-63. February.

United States Environmental Protection Agency (EPA), 2007a. *Ecological Soil Screening Levels for DDT and Metabolites.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-57. April.

United States Environmental Protection Agency (EPA), 2007b. *Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs). Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-78. June.

United States Environmental Protection Agency (EPA), 2007c. *Ecological Soil Screening Levels for Copper. Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-68. February.

United States Environmental Protection Agency (EPA), 2007d. *Ecological Soil Screening Levels for Nickel. Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-76. March.

United States Environmental Protection Agency (EPA), 2007e. *Ecological Soil Screening Levels for Zinc.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-73. June.

United States Environmental Protection Agency (EPA), 2007f. *Ecological Soil Screening Levels for Selenium. Interim Final.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-73. June.